THE BASEMENT STRUCTURE, TECTONIC HISTORY, SEISMICITY, AND SEISMIC HAZARD POTENTIAL OF THE FLORIDAN PLATEAU REGION

By

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THE BASEMENT STRUCTURE, TECTONIC HISTORY,
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By

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This study seeks to reduce subjectivity in probabilistic seismic hazard assessments in Florida by providing refined characterizations of the basement structure, tectonic history, regional seismicity, and seismic attenuation. Interpretations of digitally filtered gravity maps supplemented by previously published data reveal a basement configuration reflecting the probable translocation of fragments of Gondwanan crust during Alleghenian continental convergence and the formation of extensional basins along the southwestern half of the Floridan Plateau during Mesozoic extension. The Jay Fault zone may have originally formed as a dextral transform during continental collision, but was subsequently reactivated to accommodate sinistral and normal movement during the Mesozoic. There is no evidence for the previously hypothesized Florida Elbow

Fault. The Jurassic Tampa Basin is larger than previously mapped and the South Florida Basin region probably consists of 2-3 separate northwest-trending basins. The orientations of the Jurassic extensional basins suggest two episodes of formation, one during the rotation of the Yucatan block away from the Floridan Plateau and another during the separation of North and South America. There is no evidence of fault reactivation or other tectonic activity on the Floridan Plateau since the Middle Cretaceous.

This tectonic quiescence is manifested in the unusually low level of seismic activity on the Floridan Plateau as demonstrated by a review of regional instrumental and historical records and the deployment of a network of digital seismographs accompanied by four years of monitoring. The nonuniform distribution of regional seismic activity is probably related to the distribution and orientations of preexisting mid-crustal faults and to their propensities for slippage.

Seismic attenuation in Florida appears to be slightly higher than in the central United States, but significantly lower than the western United States. Although seismic hazard throughout Florida is extremely low, the greatest probability for damaging ground motion (> 0.2 g) exists in northwestern Florida and is calculated to be 8.0×10^{-5}/year, indicating a recurrence interval of 12,500 years. Throughout most of Florida, however, the probability of exceeding 0.2 g is significantly less than 1.0×10^{-5}/year, suggesting recurrence intervals of greater than 100,000 years.

CHAPTER 1
INTRODUCTION

Purpose

Large construction projects, such as dams, bridges, and nuclear power plants, are designed to withstand specific maximum levels and durations of strong ground motion. The projections of maximum levels and durations of strong motion are made through the use of site-specific seismic hazard analyses, which are based on a number of criteria. These criteria include the levels of historical and instrumental seismicity, the identification and characterization of seismotectonic sources, expected maximum magnitudes of earthquakes, and expected resultant ground motion at particular sites (e.g., Yegian, 1979; Johnston, 1981; Reiter, 1990). Because the Floridan Plateau has a historically low level of seismic activity and a rather enigmatic tectonic setting, little of the information needed to assess or quantify the criteria used for the analysis of seismic hazard is available.

The most reliable indicators of seismic hazard are the regional levels of historical and instrumental seismicity. The paucity of reported seismic events in the historical record suggests that the Floridan Plateau is tectonically stable. However, the sparse state population prior to this century, as well as the appreciable distance between the population centers of Florida and the western Florida

escarpment, suggests that the historical record may not provide a reliable measure of seismicity. In addition, because there has been no regional network of seismographs until recently, there is little documentation for the level of instrumental seismicity. Consequently, neither historical nor instrumental records provide reliable gauges of seismic activity for use in hazard analyses in Florida.

Another potential indicator of seismic hazard is the identification and characterization of seismotectonic sources and source regions. Seismicity in the eastern United States is generally attributed to the reactivation of Mesozoic or older faults in a moderate stress field (Sykes, 1978; Hamilton, 1981; Wentworth and Mergner-Keefer, 1983; Zoback, 1992); however, the structure of the Floridan Plateau basement is deeply buried. The crystalline basement of the plateau is overlain by Coastal Plain sedimentary deposits, which range in thickness from about 900 meters in north-central Florida to over 5000 meters in southern Florida (Wicker and Smith, 1978). As a result of this thick sedimentary sequence, there are relatively few drill holes intersecting the basement (Barnett, 1975; Smith, 1982; Chowns and Williams, 1983) and regional potential field interpretations are difficult (e.g., Oglesby et al., 1973; Klitgord et al., 1984). Consequently, current models for the structure of the Florida basement are necessarily characterized only by generalizations of large scale features and lithotectonic units, while structural details remain enigmatic. These generalized models provide little insight into the seismotectonic nature of the Floridan Plateau.

The amplitude of ground motion at a particular epicentral distance from a seismic event is dependent not only upon the seismic moment of the event, but also upon individual site characteristics and seismic attenuation. Seismic attenuation in the eastern and central United States has been studied on a regional level (Nuttli, 1973A; Jones et al., 1977; Bollinger, 1979; Campbell, 1981; Singh and Herrmann, 1983), but there have been no independent studies of attenuation in Florida. Accordingly, Nuttli's (1973A) generalized attenuation coefficients for the eastern United States are employed in calculations of seismic hazard in Florida. However, the Floridan Plateau has been shown to be an allochthonous terrane with respect to the North American craton (e.g., Smith, 1982). This suggests that the mechanical response of the plateau may differ from that of the remainder of the eastern United States, which would invalidate the use of Nuttli's attenuation coefficients. As a result, estimations of expected ground motion in Florida may be invalid.

One consequence of the limitations inherent in the historical and instrumental records in Florida and the enigmatic nature of the tectonics and structure of the basement is that the criteria used in regional seismic hazard analyses (i.e., seismicity, seismotectonic characterizations, and seismic attenuation) are poorly documented. Previous seismic hazard analyses in Florida have assumed, with little substantiation, that the risk of local seismic activity is negligible and that Nuttli's eastern United States attenuation coefficients are applicable to the Floridan Plateau (e.g., Ebasco, 1988). The purposes of this study are to utilize a variety of geophysical methods to further investigate each of the criteria used in seismic hazard

analyses and to reexamine the tectonic history of the region. Specifically, the intention is to provide improved characterizations of the basement structure, tectonic evolution, regional seismicity, and seismic attenuation in the Floridan Plateau region, and to incorporate these into an empirical assessment of seismic hazard in Florida.

Methodology

Several geophysical methods have been employed and incorporated into this study. In each of the following chapters, the methods used are discussed in detail. The purpose of this section is to provide a general overview of the sequence of these individual methods and how each has been utilized in this study.

The first step of the study was to digitize and filter potential-field data for the entire Floridan Plateau. The resultant filtered gravity maps for the Plateau, when interpreted in conjunction with previously published magnetic, drill hole, seismic reflection, and seismic refraction data, permitted an improved resolution of the locations, sizes, natures, and spatial relationships between the various crustal blocks and structural features of the plateau basement. A tectonic interpretation based on this improved structural model prompted a general interpretation of the seismic history of the plateau, and existing seismic reflection studies of the Cenozoic sedimentary accumulations overlying the basement allowed a more specific determination of recent levels of seismic activity.

The next step was to investigate the nature of seismicity in the southeastern United States. This involved a review of historical records, particularly those from Florida, and instrumental records,

which only encompass the past twenty years in this region. Because instrumental coverage in Florida was insufficient, a network of digital seismographs was established for the purposes of attempting to detect and characterize any previously unknown local sources of seismic activity and to characterize the local mechanical response of the crust to regional events. The information compiled from these historical and instrumental sources was then examined within the context of previously published regional stress field indicators to develop a lithospheric model for the distribution of earthquakes in the southeastern United States.

Following this, each of the seismic source provinces in the southeastern United States, the Caribbean, and the Gulf of Mexico in which activity could potentially generate significant ground motion in Florida were identified. Each province was characterized based on the compiled earthquake information, the lithospheric models for the Floridan Plateau and the southeastern United States, and previously published material. Included in the characterizations were estimates of maximum magnitude and recurrence intervals.

Subsequently, a method was developed to estimate a local value of seismic attenuation in Florida. This method utilizes isoseismal maps as a means of approximating the decrease in peak ground acceleration with distance from an event with a known or reasonably well-approximated magnitude. These parameters (acceleration, distance, and magnitude) are then used to mathematically derive a value for seismic attenuation. It was necessary to test and validate this method using isoseismal maps from various earthquakes in the central and western United States,

where attenuation coefficients are well known. Once validated, the method was applied to the isoseismal maps from the 1886 Charleston earthquake and a 1973 earthquake in northeastern Florida in order to estimate attenuation coefficients for the southeastern Coastal Plain and Florida.

Finally, the source zone characterizations and estimated attenuation coefficients were used as input for a probabilistic seismic hazard assessment for Florida. This analysis is based on the method of Cornell (1968), which addresses the effects of all of the possible earthquakes likely to affect Florida for each site on a grid of sites around the state. Based on the distances to each seismic source zone, recurrence intervals, and seismic attenuation coefficients, a value is calculated for each site describing the probability that a particular acceleration will be exceeded at that site within a given time frame. The resulting grids were contoured to produce probabilistic seismic hazard maps for Florida.

CHAPTER 2
THE STRUCTURE OF THE FLORIDAN PLATEAU

Introduction

All regional models describing the structural features of the Floridan basement have been founded primarily on deep drill hole data from wells penetrating pre-Cretaceous crystalline rock. Because of an intrinsic bias in the spatial distribution of these drill holes, most of the regional models have been limited in scope to peninsular Florida, rather than to the entire Floridan Plateau. Similarly, more localized, yet more detailed, structural models based on seismic reflection profiles tend to be spatially biased towards offshore areas. As a result, with the notable exception of Klitgord et al. (1984), there has been little effort to integrate previously published studies into an examination of the Floridan Plateau as a singlar feature.

Since the work of Klitgord et al., a number of pertinent geochemical, geophysical, and drill hole studies have been published (e.g., Nelson et al., 1985A; Ball et al., 1988; Heatherington et al., 1989; Dobson, 1990; Heatherington and Mueller, 1991; McBride, 1991); these have yet to be examined within a regional context. The intention in this chapter is to utilize digitally filtered regional potential-field data as a means of consolidating a large number of disparate drill hole, geophysical, and geochemical observations into a single model for the structure and tectonics of the Floridan Plateau.

Methods of Investigation

A series of digital geophysical and structure contour maps for the Floridan Plateau were produced for this investigation using the methods described in Lord (1992). These maps cover the rectangular area encompassed by 24 to 31 degrees north latitude and 80 to 86 degrees west longitude. All of the digitizing, digital filtering operations, and contouring were done on a IBM 386 compatible, equipped with a Houston Instruments digitizing tablet. Additional drafting and figure preparation were done on an Apple MacIntosh IIci equipped with a scanner and laser printer. Commercial software packages employed include Rockware's Digitize, Golden Software's Surfer, Lotus 1-2-3, Silicon Beach Software's Superpaint, and a series of potential-field geophysical programs available through the USGS (Hildenbrand, 1983; Grauch, 1984; Godson and Mall, 1989).

The first step was to produce a detailed depth-to-basement map for the plateau. In this study area, basement is defined by the unconformity between pre-Late Jurassic rocks and younger sedimentary accumulations of the Coastal Plain. All available drill hole depth-to-basement data, shown in Figure 1, were plotted on a grid representing points with a 9.2 km spacing over the study area. Sources for these data include Barnett (1975), Smith (1982), Chowns and Williams (1983), Schlager et al. (1984), Ball et al. (1988), and Dobson (1990).

A number of additional depth-to-basement determinations were then made from previously published seismic reflection, seismic refraction, and gravity studies (e.g., Antoine and Harding, 1965; Sheridan et al., 1966; Arden, 1974; Mitchum, 1978; Sheridan et

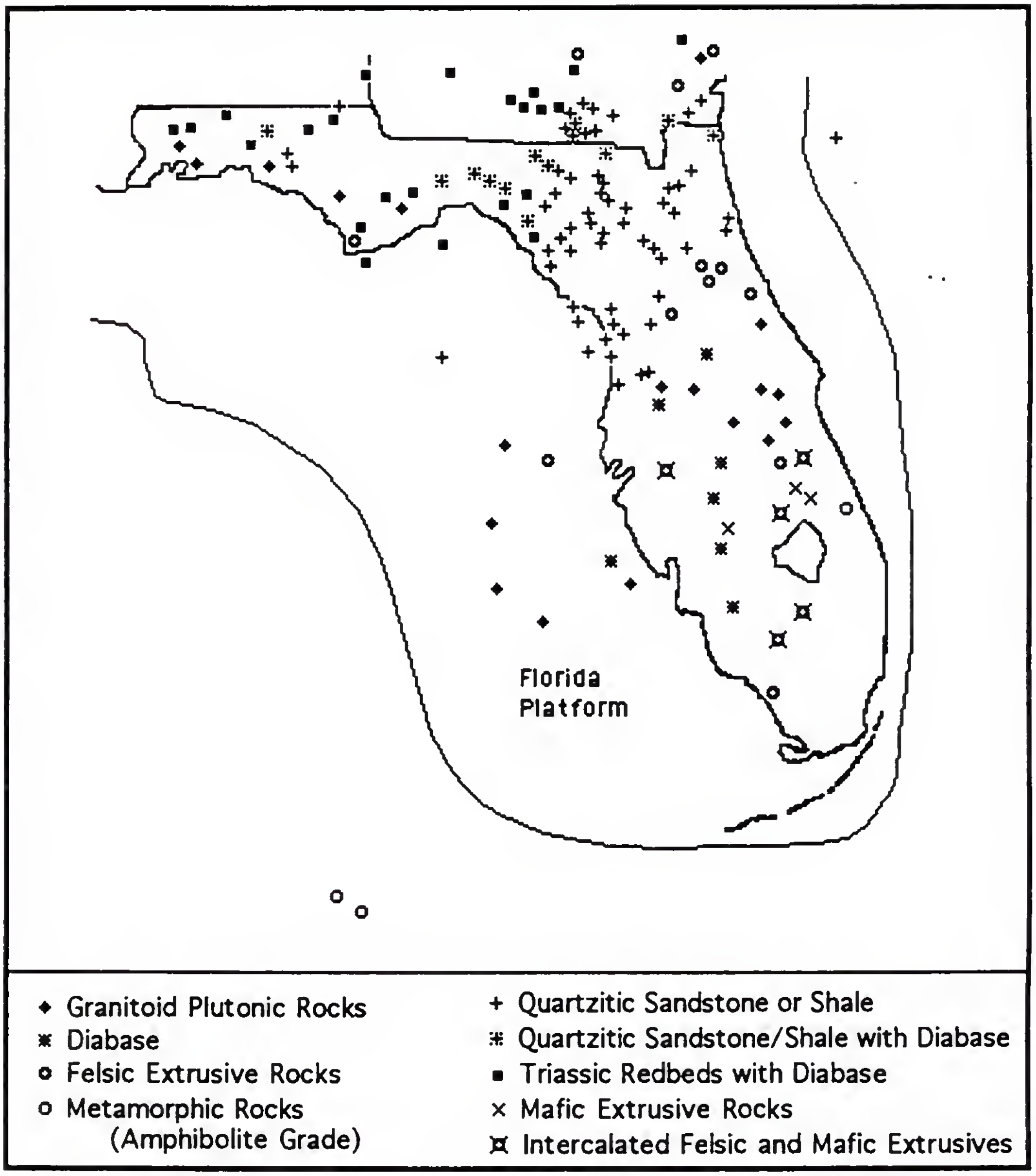


Figure 1. Drill hole locations and basement lithologies within the study area. (Compiled from Barnett, 1975; Smith, 1982; Chowns and Williams, 1983; Schlager et al., 1984; Ball et al., 1988; Dobson, 1990.)

al., 1981; Schlager et al., 1984; Shaub, 1984; Dillon et al., 1985; Nelson et al., 1985A; Lord, 1987; Ball et al., 1988; McNeely, 1988; Mullins et al., 1988; Winker and Buffler, 1988; Dobson, 1990; McBride, 1991). Figure 2 is a location map compiled from these geophysical surveys. In those seismic studies in which the original authors had not made time-depth conversions, drill hole depth data were used to provide controls for these conversions. Where this drill hole control is not available, such as in deeper areas, time-depth conversions are largely subjective. These depth determinations were then plotted on the appropriate points on the grid. Depth-to-basement values were interpolated to each remaining point and the grid was subsequently digitized and contoured. The final map is shown in Figure 3.

A Bouguer anomaly map of the study area was produced as well. This map, which is shown in Figure 4, is essentially a digitized and recontoured version of that produced by Klitgord et al. (1984), although an older map by Oglesby et al. (1973) was extensively utilized as well. The original Klitgord map was constructed through the compilation of several different maps from several different studies and, consequently, there are minor inconsistencies at the borders between these study areas. In addition, their map has a small data-less area extending along the northwestern coast of peninsular Florida (Klitgord et al., 1984, pg. 7760, fig. 8).

For the purposes of digital filtering, it was desirable to produce a single, continuous data set for the study area. In order to accomplish this, it was necessary to eliminate these discrepencies by extrapolating values across the borders and data-less area, as apparently was done in the Oglesby map. Although this may

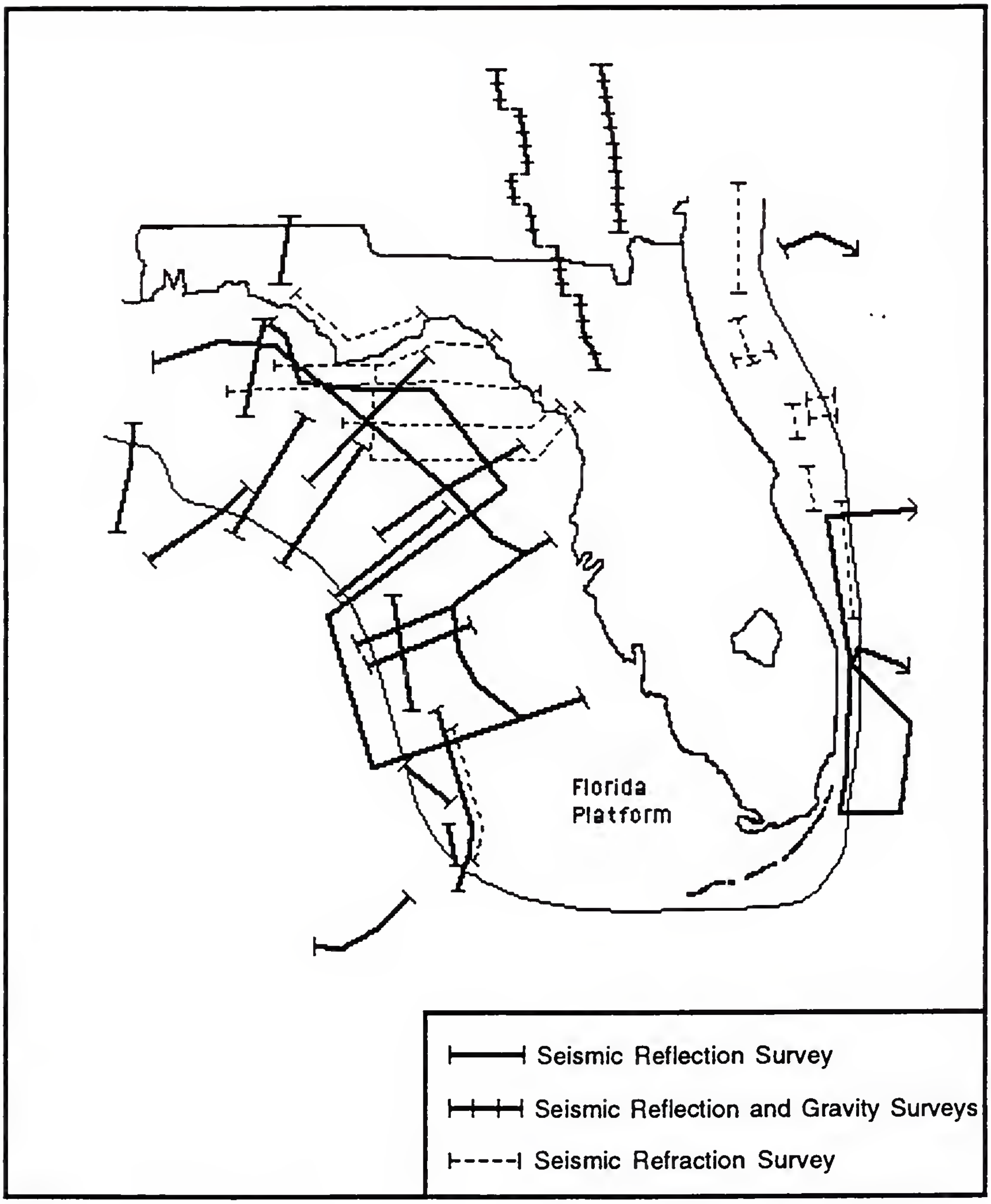


Figure 2. Geophysical survey locations within the study area. (Compiled from Antoine and Harding, 1965; Sheridan et al., 1966; Arden, 1974; Mitchum, 1978; Sheridan et al., 1981; Schlager et al, 1984; Shaub, 1984; Dillon et al., 1985; Nelson et al., 1985A; Lord, 1987; Ball et al., 1988; McNeely, 1988; Mullins et al., 1988; Winker and Buffler, 1988; Dobson, 1990; McBride, 1991.)

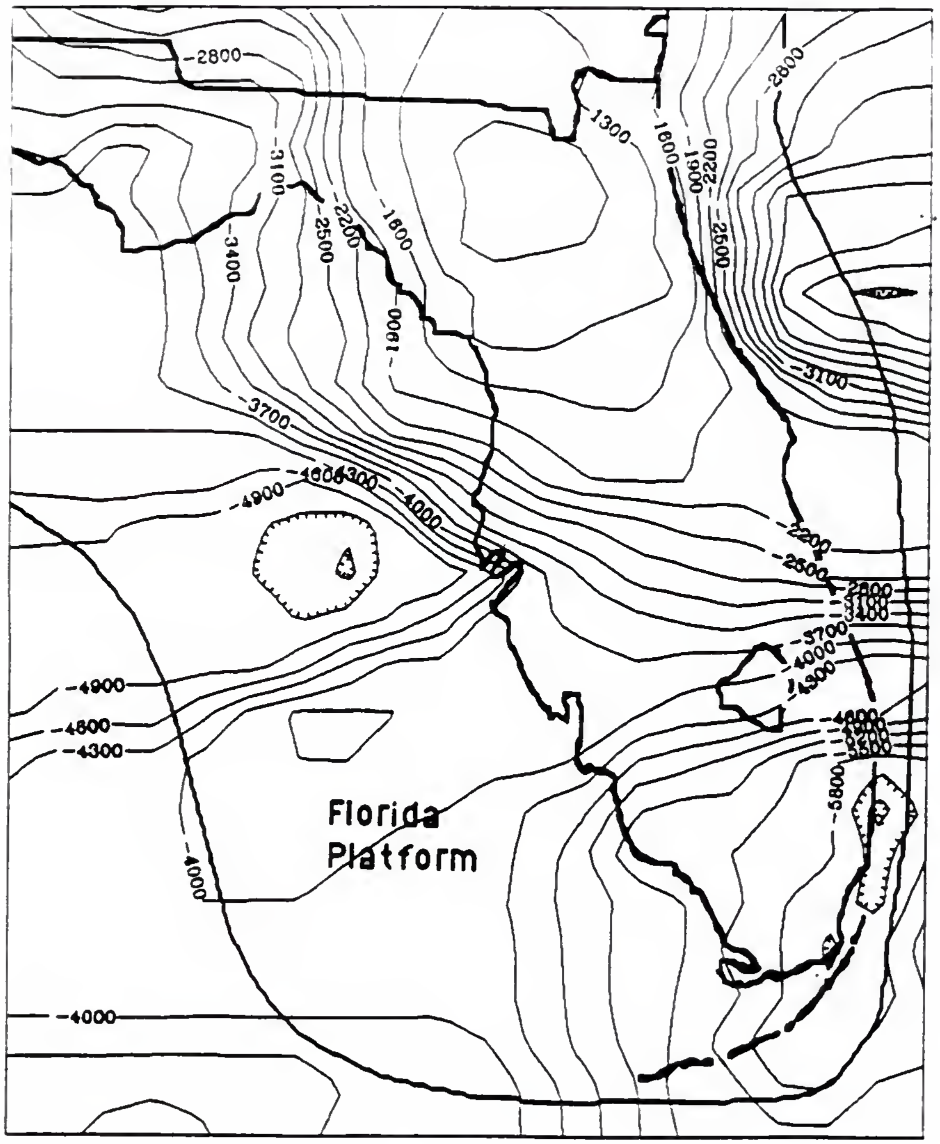


Figure 3. Depth-to-basement of the Floridan Plateau. Contour interval = 300 meters.

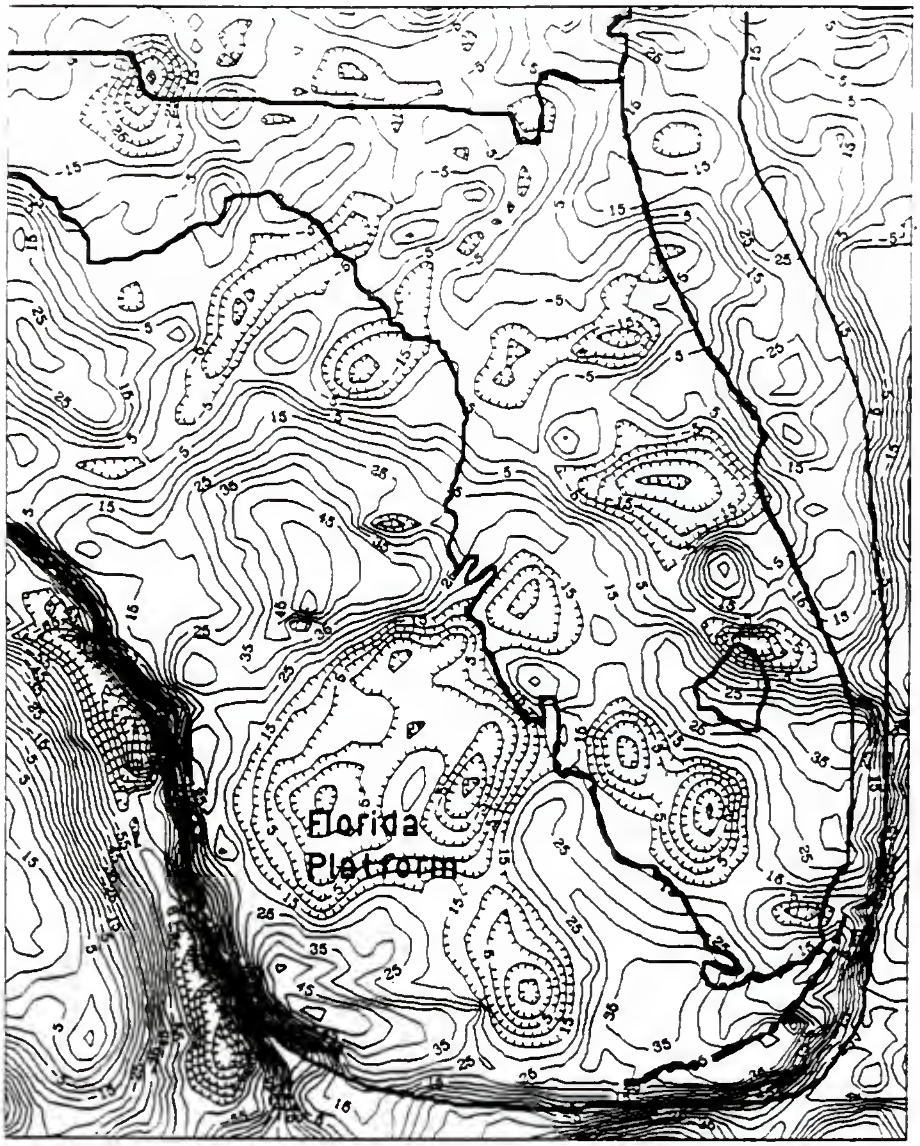


Figure 4. Bouguer anomaly map of the Floridan Plateau region. (Compiled from Oglesby et al., 1973; Klitgord et al., 1984.) Contour interval = 5 mgals.

introduce some error, it is believed that any such error will be minimal. As with the depth-to-basement map, the Bouguer anomaly map was digitized on a rectangular grid with a 9.2 km spacing, which was chosen to conform to software limitations while maximizing the number of data points. The resulting 6696 data points were then contoured with a 5 milligal contour interval using the Surfer software package.

A magnetic anomaly map (Figure 5) was also constructed, using data from King (1959), Gough (1967), and Klitgord et al. (1984). The data were digitized from these original maps and contoured using a 50 nanotesla contour interval. Unfortunately, there are relatively large areas of the plateau for which there are no data. The digital filters used in this study employ Fourier synthesis to transform the data from the space domain to the frequency (or wave number) domain. As a consequence of Gibbs phenomenon, that is, the error introduced during Fourier synthesis near a discontinuity, it was determined that the data-less areas in the magnetic anomaly map would result in unacceptable errors should the magnetic data set be digitally filtered. As a result, the use of an unfiltered magnetic anomaly map for the plateau is considered to be more desirable for interpretive purposes.

Because this map represents a compilation from a number of magnetic surveys (e.g., Klitgord et al., 1984), the anomaly values from different sections of Figure 5 may be derived from several different base values. While similarities between this map and the previously published magnetic anomaly maps suggest that this has not significantly affected the shape or magnitude of the local

magnetic anomaly patterns presented in Figure 5, there is undoubtedly some error in the relative magnetic values between any given area and values in other sections of the map.

The Bouguer anomaly data were digitally filtered using several methods and a series of maps were created from the filtered data. These digital filters included a downward continuation (Figure 6), an upward continuation (Figure 7), and a second vertical derivative (Figure 8) of the Bouguer anomaly field. The purposes of these filters are explained below. In each case, several rows and columns of extrapolated data were added to each side of the grid to reduce the near-boundary distortion of Gibbs phenomenon. These additional rows and columns were then removed prior to contouring.

The downward continuation of potential-field data was done from a level to an irregular surface using the method of Grauch (1984). This method is used to approximate the relative values of gravitational potentials at the basement surface. Because the depth-to-basement is quite variable, ranging from about 850 m to over 6000 m, the removal of resultant depth-related deviations in the observed field through this method of downward-continuation might be expected to reveal previously unobserved trends or features. In addition, downward continuation has the effect of sharpening the field, which better outlines source features at depth.

The application of downward-continuation filters, either in the frequency or space domains, results in a biased amplification of higher frequency (or smaller) components relative to lower frequency (or larger) components (Clarke, 1969; Cordell and Grauch,

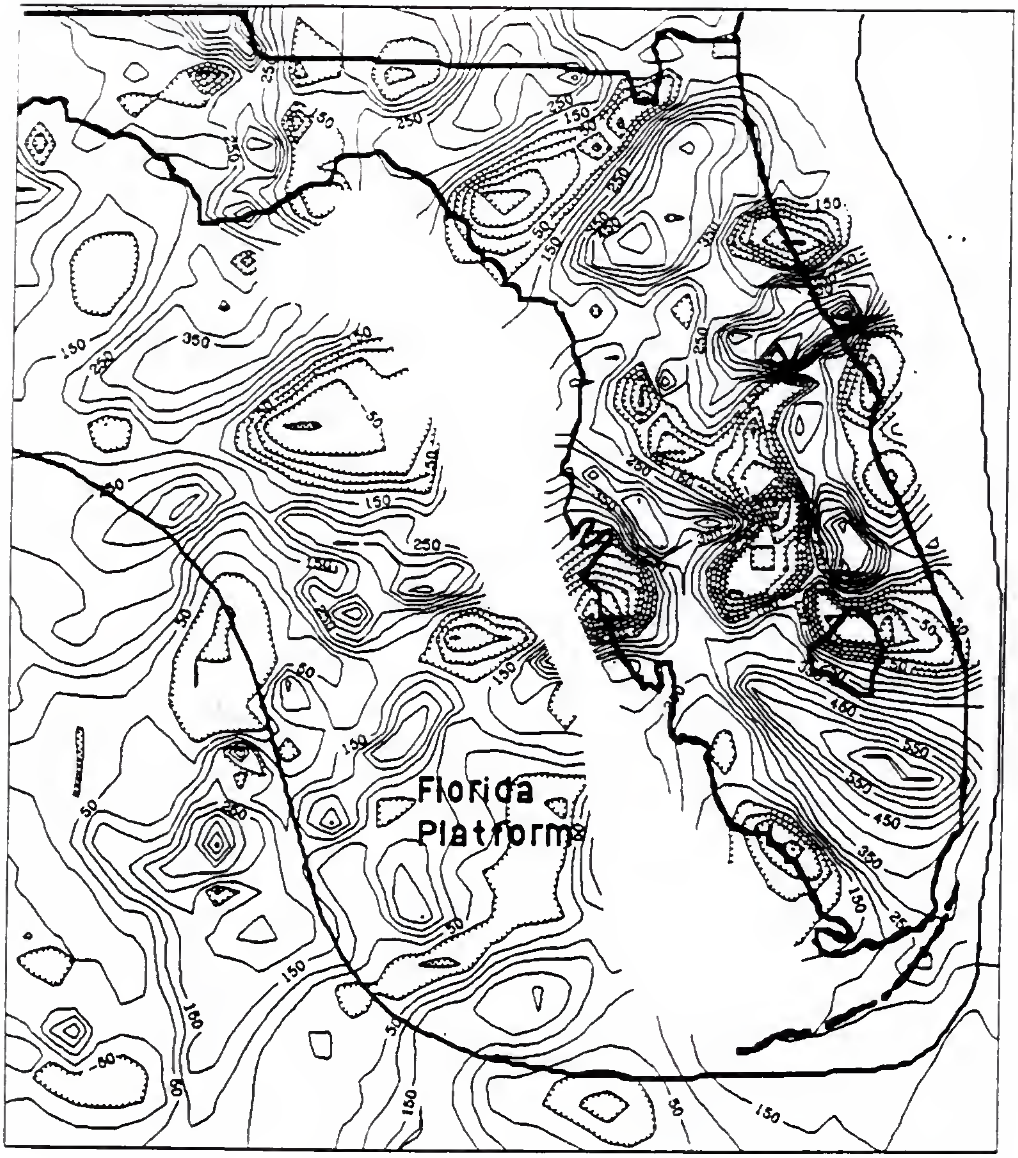


Figure 5. Magnetic anomaly map of the Floridan Plateau region. (Compiled from King, 1959; Gough, 1967; Klitgord et al., 1984.) Contour interval = 50 nT.

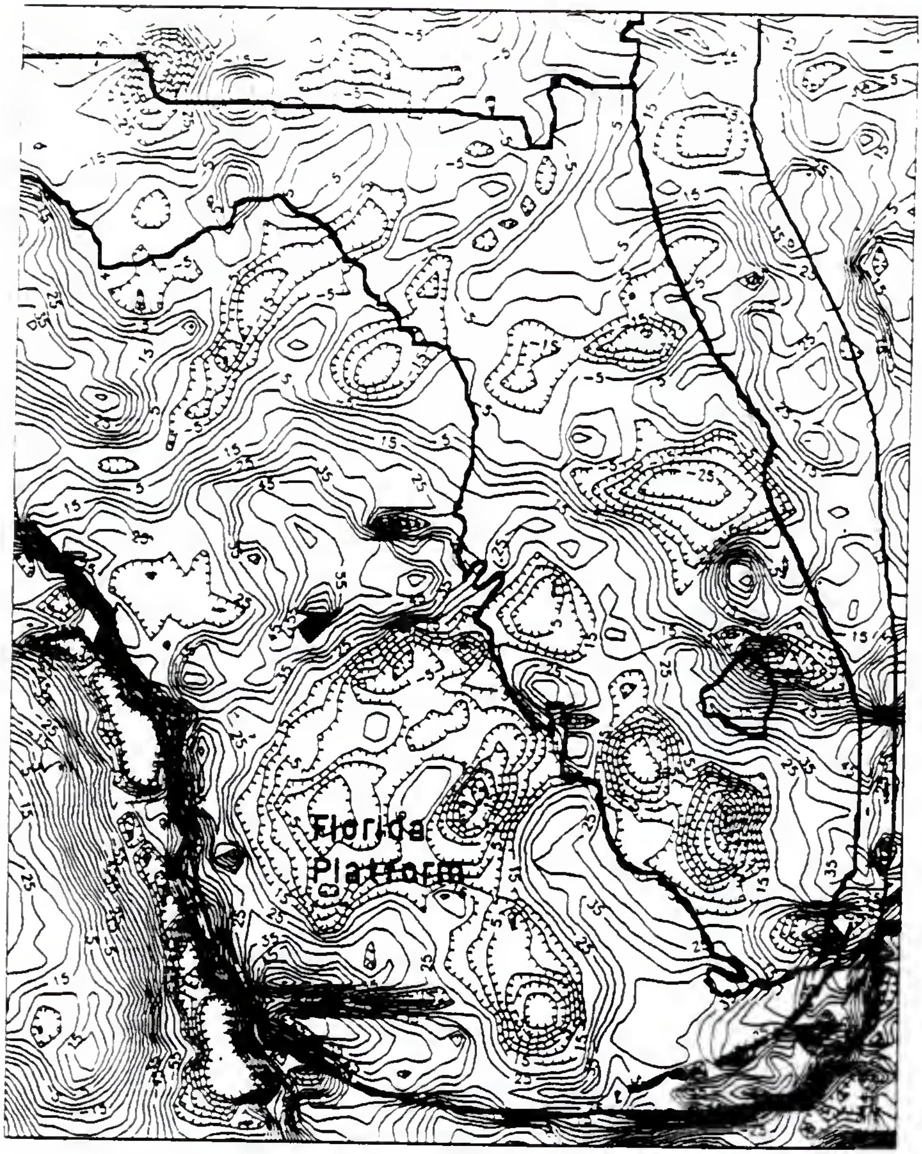


Figure 6. Bouguer anomaly field of the Floridan Plateau downward-continued to basement level. Contour interval = 5 mgals.

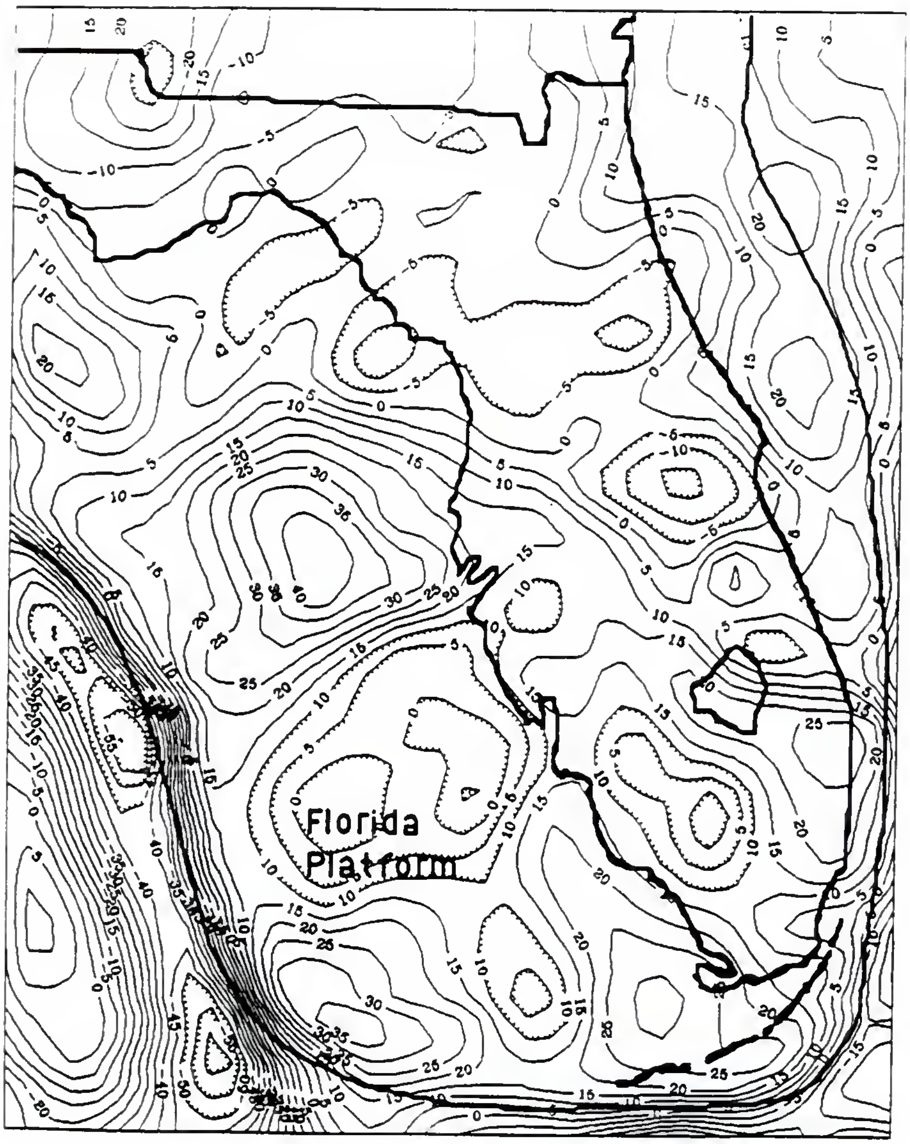


Figure 7. Bouguer anomaly field of the Floridan Plateau upward-continued to 10 km. Contour interval = 5 mgals.

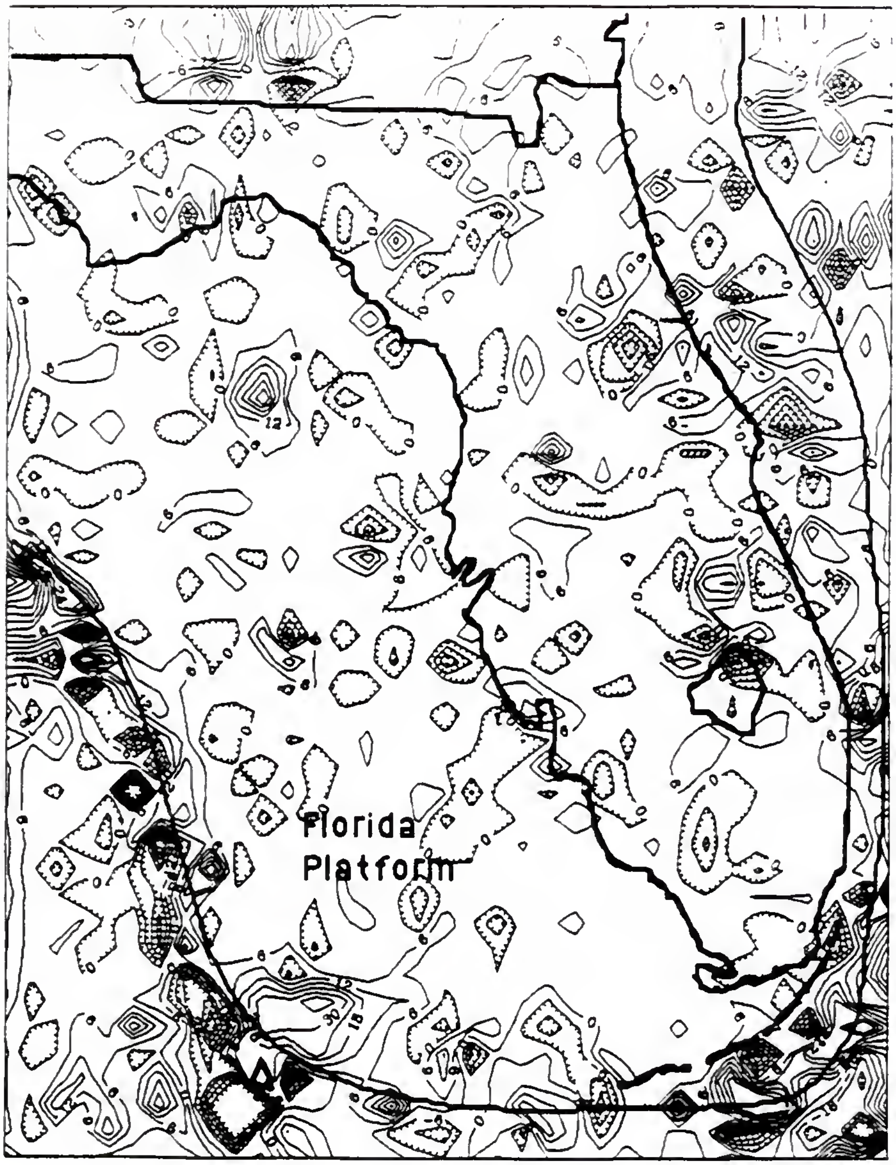


Figure 8. Second vertical derivative of the Bouguer anomaly field of the Floridan Plateau. Contour interval = 6 mgals.

1982). This necessitates the use of a low-pass filter prior to performing these operations.

In order to apply this low-pass filter, the gridded data set is transformed into the frequency, or wave number, domain through the use of the two-dimensional Fast Fourier transform (or FFT). The FFT is simply an efficient method of calculating the Discrete Fourier transform (or DFT), which, in turn, is a digital method of approximating the continuous Fourier integral function (Cooley and Tukey, 1965; Bergland, 1969). The two-dimensional FFT is given by

$$G(k,l) = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} g(m,n)\ e^{-2\pi i \left(\frac{km}{M} + \frac{ln}{N} \right)}$$

where G(k,l) is the potential-field function, with k and l representing grid point locations in the frequency domain, m and n are integers representing grid point locations in the space domain, M is the number of rows, and N is the number of columns (Hildenbrand, 1983). Once in the frequency domain, a tapered low-pass filter was applied; this progressively filtered out wavelengths from 36.8 km to 18.4 km, while wavelengths below 18.4 km (high frequencies) were totally squelched. The data set was then transformed back to the space domain through the application of the inverse FFT (or IFFT).

For the actual downward continuation, the method of Grauch (1984) utilizes a Taylor series expansion to approximate the potential-field data, f(z), at some depth, z, from the observed potential-field data, f(0), at a given reference level, z = 0. The Taylor series, which was calculated to 3 terms, is given by:

$$F(z) = F(0) + z \frac{\partial}{\partial z} f(0) + \frac{z^2}{2} \frac{\partial^2}{\partial z^2} f(0) + \ldots$$

The z value for each grid location was taken from the depth-to-basement data already described. This calculation was repeated for each point on the grid, the added boundary data were removed, and the resultant data set subsequently contoured (Figure 6).

Another filter applied to the Bouguer anomaly field was an upward-continuation to an elevation of 10 km. This has the effect of removing short-wavelength features of the field, which are often attributable to shallow crustal sources (Figure 7). The upward-continuation is accomplished by taking the FFT of the data as described above, giving the Fourier coefficients G(k,l). As described by Fuller (1967), these Fourier coefficients are then multiplied by H(k,l), the wave number response of the filter. H(k,l) is given by

$$H(k,l) = e^{2\pi z (k^2 + l^2)^{\frac{1}{2}}}$$

where z is the continuation distance. The application of the IFFT to the gridded data and the removal of the added boundary data then permitted the construction of the final upward-continued map.

In a similar manner, a second vertical derivative map was also produced. The second vertical derivative effectively removes long-wavelength features from the field while emphasizing those short-wavelength features usually attributable to shallow crustal sources (Figure 8). In this instance, the data set was transformed into the

frequency domain and the Fourier coefficients subsequently multiplied by the wave number response of the filter as given by

$$H(k,l) = 4\pi^2(k^2 + l^2) \qquad \text{(Fuller, 1967)}$$

Again, the data set was then transformed back into the space domain using the IFFT, the extra boundary data removed, and the grid subsequently contoured.

Results and Interpretations

In general, these maps complement and augment the results of many previous investigations. The depth-to-basement map accurately depicts the Peninsular Arch, the expected southward increase in depth, the series of Mesozoic basins in the southern and western regions of the plateau, and a small previously undescribed basin under the northeastern edge of the plateau (Figure 3).

While the differences between the original Bouguer anomaly map (Figure 4) and the downward-continued map (Figure 6) are relatively subtle, the downward continuation is preferable as it more accurately delineates the boundaries of anomaly-producing features. The upward-continued map (Figure 7) delineates a number of long-wavelength features that are clearly associated with large scale crustal features, such as the Mesozoic basins, that have been previously described, but poorly located and characterized. On the other hand, the second vertical derivative map (Figure 8) shows relatively few short-wavelength features on the plateau, and these are all low amplitude. This suggests that the sedimentary

accumulations of the Florida Platform are relatively homogeneous with respect to density. Furthermore, it suggests that smaller shallow crustal features, such as plutons, are not particularly abundant on the plateau, although this does not preclude the existence of such features with low density contrasts or in the middle crust.

Pre-Mesozoic Features of the Plateau Basement

The lithologies of the pre-Mesozoic basement terranes of the northeastern portion of the plateau have been moderately well characterized. Basement lithologies from the remaining portions of the plateau are unresolved; however, more structural detail is known. As a result, this section will necessarily be focused on the pre-Mesozoic lithotectonic terranes of northern peninsular Florida, while the next section will be focused primarily on the Mesozoic structural features of western Florida. In the following discussion, the location of each of the lithotectonic features or regions within the study area is designated by a letter on Figures 9-15.

Osceola Granite--region A. The Osceola Granite, previously known as the Avalon terrane, is the oldest identified terrane in the plateau basement. Although described as a granite by convention, it is better characterized as a relatively undeformed granitoid batholith composed of a range of felsic lithologies (Milton and Grasty, 1969; Barnett, 1975; Smith, 1982). This granitoid complex underlies the east central portion of the plateau at an average depth of about 2100 m (Figure 10). Using Rb/Sr techniques, Bass (1969) dated the Osceola Granite at about 530 Ma.; a similar age has subsequently

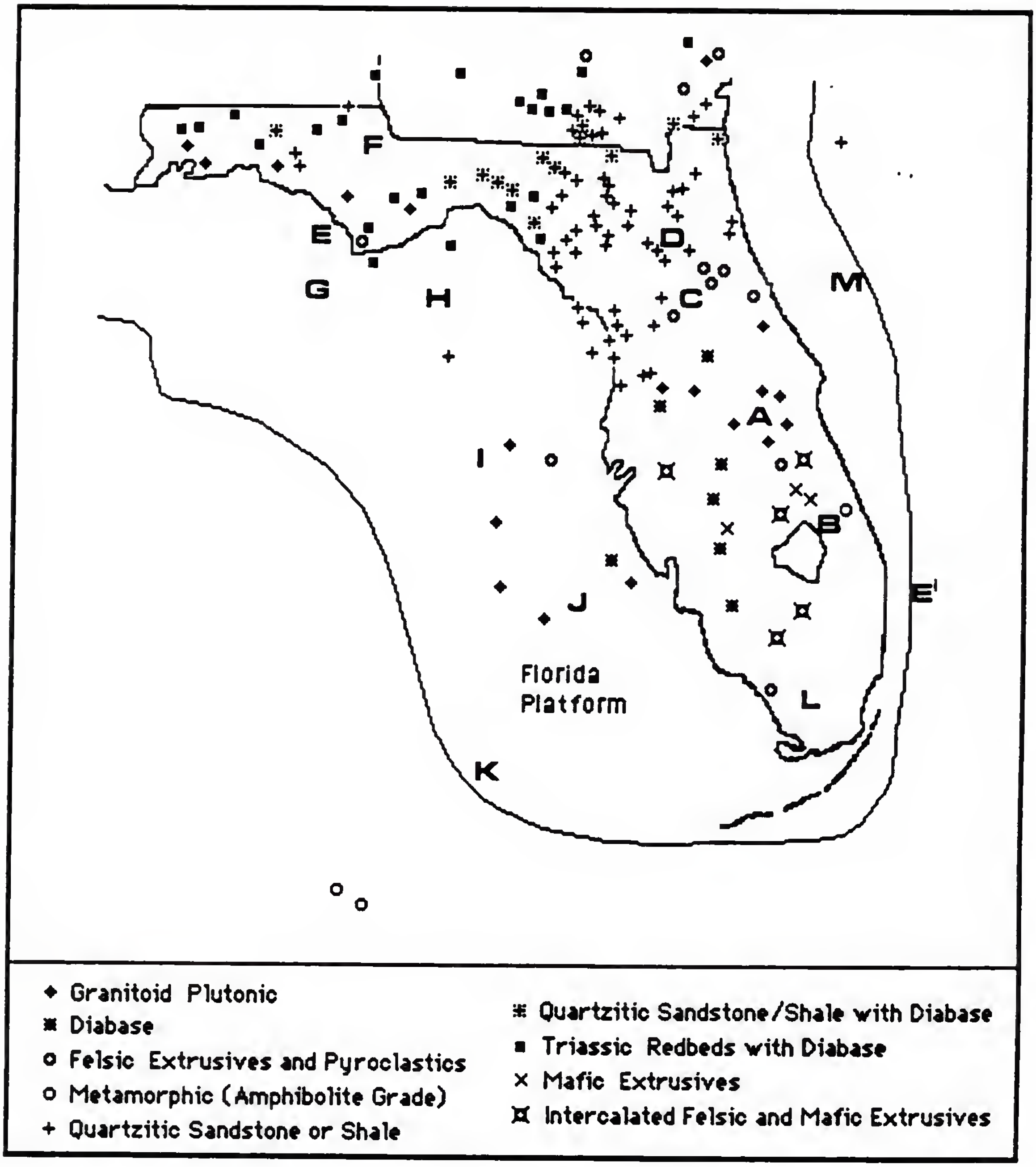


Figure 9. Map of drill hole distribution and basement lithologies with the designated features discussed in the text.

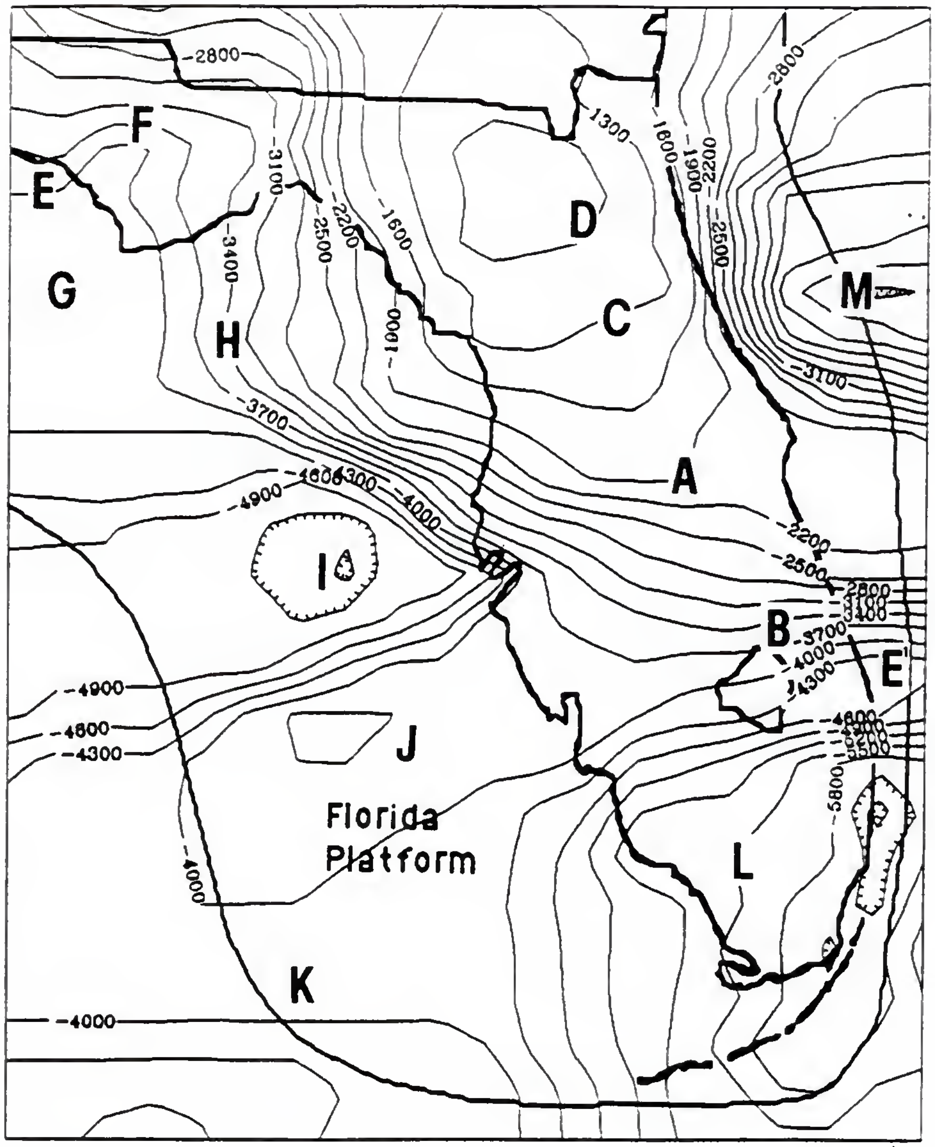


Figure 10. Depth-to-basement map with the designated features discussed in the text.

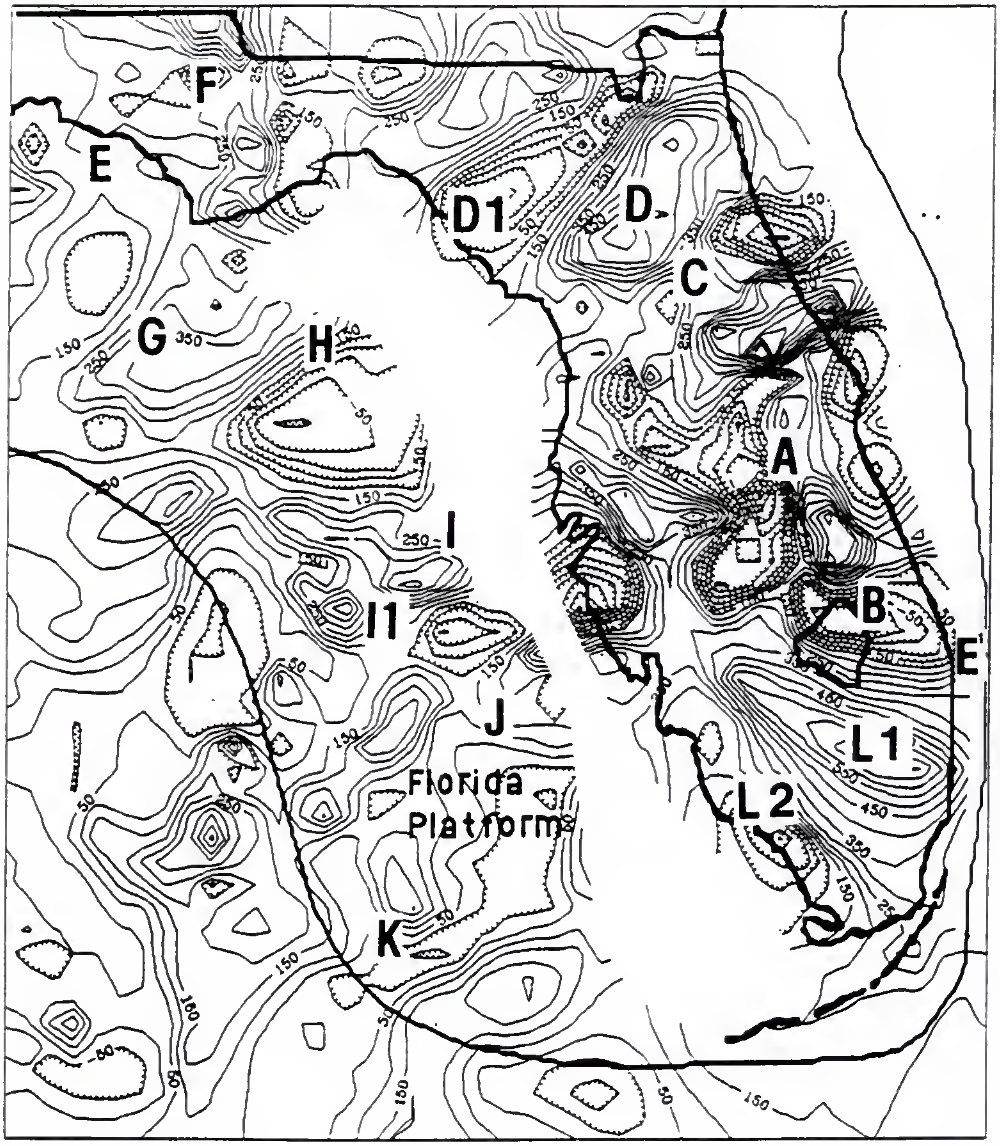


Figure 11. Magnetic anomaly field map with the designated features discussed in the text.

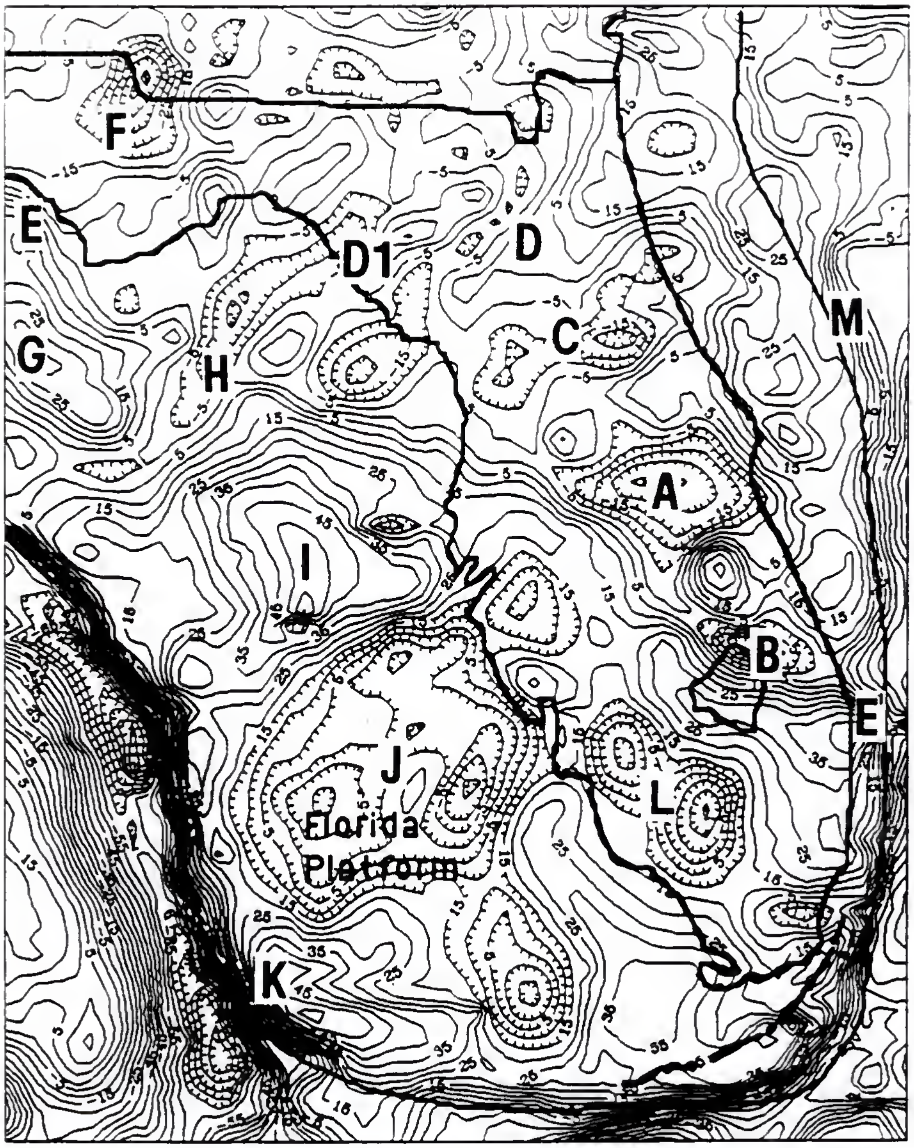


Figure 12. Bouguer anomaly map with the designated features discussed in the text.

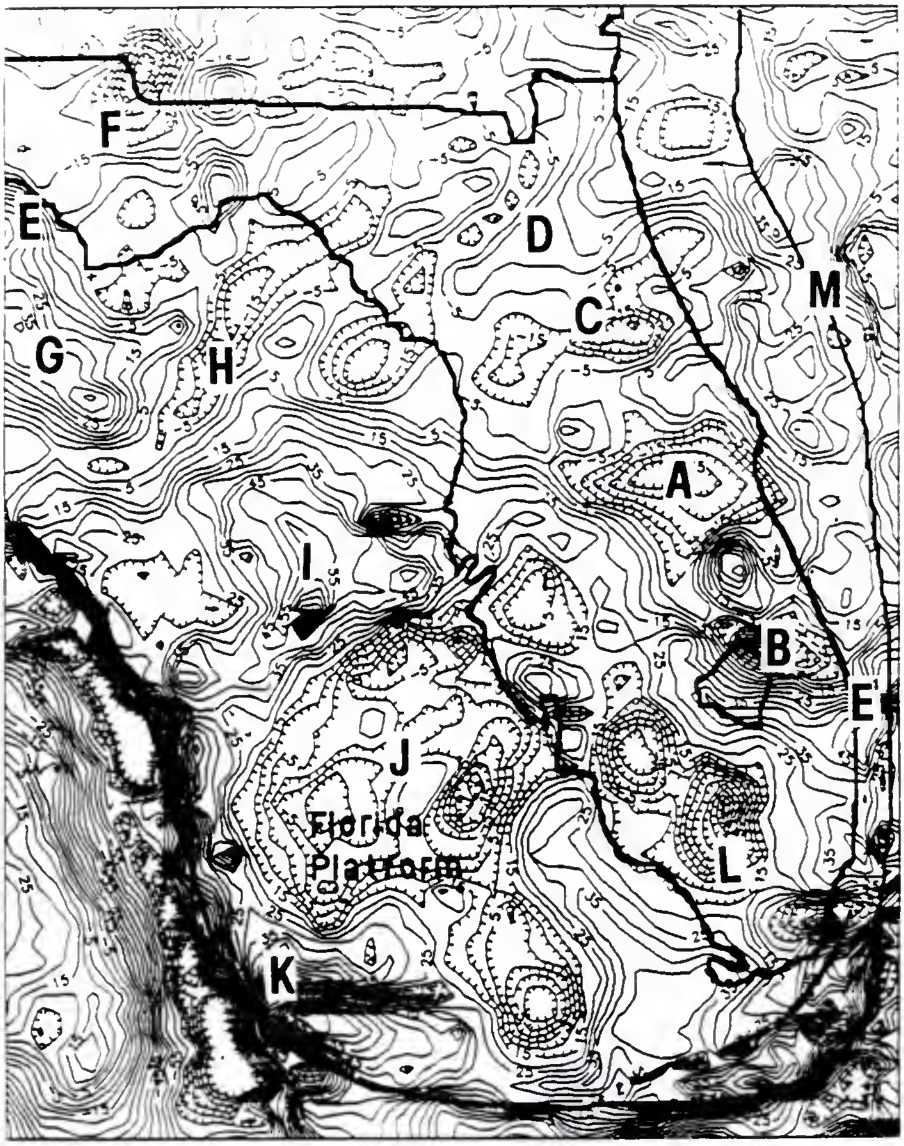


Figure 13. Downward-continued Bouguer anomaly map with the designated features discussed in the text.

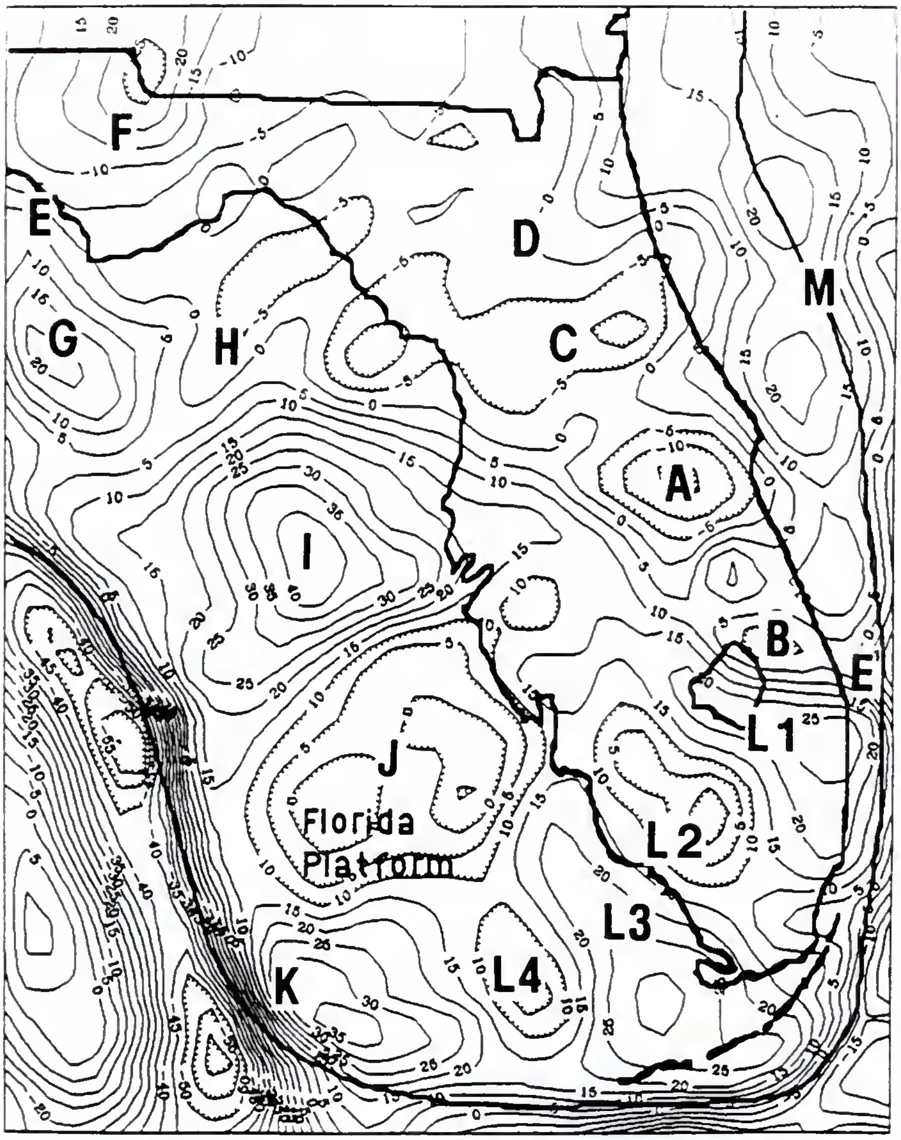


Figure 14. Upward-continued Bouguer anomaly map with the designated features discussed in the text.

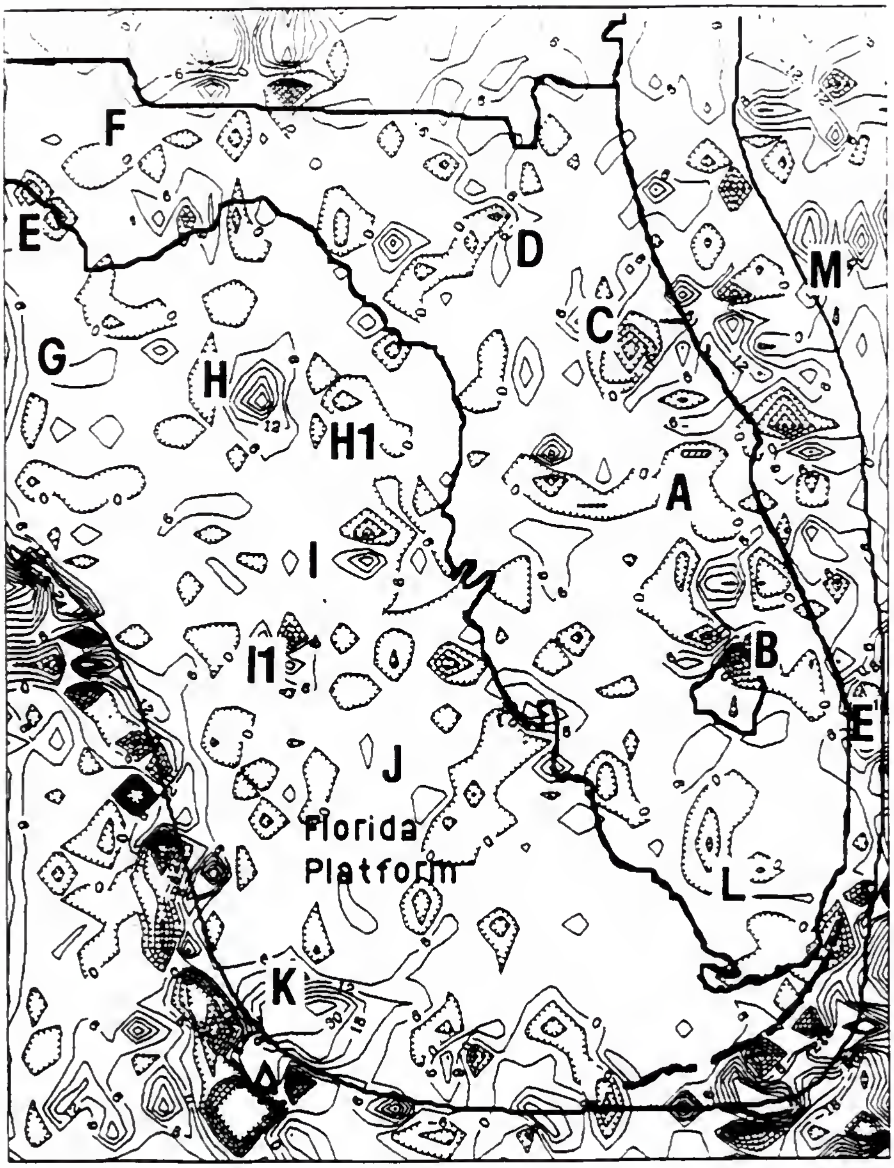


Figure 15. Second vertical derivative of the Bouguer anomaly field with the designated features discussed in the text.

been obtained by Dallmeyer et al. (1987) using 40Ar/39Ar techniques on a composite biotite sample from several specimens. Sm-Nd isotopic data for the Osceola Granite are suggestive of a mixed source containing both Proterozoic and Archean components (Heatherington et al., 1989).

The 8 drill holes intersecting granite in east-central Florida are generally centered around a pentagonal negative gravity anomaly (Figures 9, 13, 14--A), although several of these holes are outside the boundaries of the anomaly. The magnetic signature of the terrane is more complex, as the easternmost of the holes are located along a north-south oriented, elongated positive magnetic anomaly, while most of the others are located within the confines of a proximal negative magnetic anomaly (Figure 11--A). The north-south oriented boundary between these magnetic features bisects the negative gravity anomaly.

Barnett (1975) modeled the Osceola Granite as constituting the block-faulted end cap of the Peninsular Arch, a hypothesized structural high under north-central Florida. Although the Peninsular Arch has since been described as an erosional feature (Smith, 1982) and the Osceola Granite shows little petrologic evidence of metamorphism (Milton and Grasty, 1969), the possibility of block faulting remains. The randomness and variability in depth-to-basement for the 8 drill holes is suggestive of block-faulting, as is the variability in both the gravity and magnetic fields in the area described by those drill holes (Figures 11 and 13). In addition, it appears that the Osceola Granite has been intruded by diabase, as

suggested by the number of drill holes that have bottomed in weathered diabase throughout the area (Figure 9).

The contacts between the Osceola Granite and the juxtaposed terranes are not well constrained. A primary reason for this arises from the inherently poor resolution of isotopically determined ages for the North Florida Rhyolite to the north (Mueller and Porch, 1983) and the St. Lucie Metamorphic Complex to the southeast (Bass, 1969). As a result, the fundamental age relationships between the three terranes remain undetermined and age-based inferences concerning the nature of the contacts between them are ambivalent. A number of contradictory suggestions have been made.

For example, Chowns and Williams (1983), citing the apparent concordance in ages between the Osceola Granite and the amphibolite, suggested that they could comprise a conterminous terrane. Accordingly, the rhyolitic terrane would then overlie both the granite and amphibolite, and be separated from them by a thrust fault or unconformity. Alternatively, Bass (1969) believed that the St. Lucie amphibolite, by reason of metamorphic grade, must necessarily be separated from all other Florida basement rocks by a "fundamental discontinuity." This was supported by the presence of thin layers of unaltered basaltic rock, granite, and diorite immediately over the amphibolite, which implies a horizontally faulted contact (Bass, 1969). Another possibility is that the Osceola Granite represents an intrusion into an older terrane consisting of the rhyolite and the metamorphic complex (Barnett, 1975). In support of this latter model, Thomas et al. (1989) inferred from interpreted steep, circular gravity and magnetic gradients around the Osceola

Granite that it is bounded by steeply dipping contacts with the surrounding lithologies.

Samples from several drill holes show that the Osceola Granite extends northeastward and northwestward beyond the boundaries inferred from the potential-field gradients; however, to the south, other holes penetrate rocks indicating that the steep gradients mark the boundaries of the terrane (Figures 9, 11, 13--A). Along its southwestern boundary, the Osceola Granite appears to be truncated by the Jay Fault, as has been suggested by Smith (1982). To the southeast, the presence of both mafic and felsic extrusive rocks in drill holes near to those intersecting the Osceola Granite clearly delineates the boundary, which coincides with steep, northeast-trending gravity gradients separating the pentagonal negative anomaly from a smaller ovoid positive anomaly. It is unclear whether the extrusive rocks overlie the granitoid or rather have been juxtaposed against it. The eastern boundary of the Osceola Granite is unresolved, although the steep north-northeast trending gravity gradient along the eastern side of the pentagonal negative anomaly suggests that the granitoid may not extend beyond the coast of peninsular Florida.

St. Lucie Metamorphic Complex--region B. A single drill hole has revealed the presence of an amphibolite grade metaigneous assemblage at a depth of about 3760 m immediately southeast of the Osceola Granite, underlying St. Lucie County (Bass, 1969; Milton and Grasty, 1969; Barnett, 1975; Smith, 1982; Chowns and Williams, 1983; Winston, 1993). Using Rb/Sr techniques, Bass (1969) dated samples of this assemblage at about 530 Ma, which is also the

approximate age obtained for the Osceola Granite. The assemblage is comprised primarily of amphibolite, with some quartz diorite gneiss and chlorite schist (Bass, 1969; Thomas et al., 1989). Although several names have been applied to this terrane, in this work it will be referred to as the St. Lucie Metamorphic Complex.

The drill hole is located near the northern edge of an ovoid east-west oriented negative gravity and magnetic anomaly. This anomaly is relatively small, approximately 100 km long by 55 km wide, and may delineate the boundaries of the terrane (Figures 11 and 13--B). It is probable that the St. Lucie Complex is bounded to the southwest by the Jay Fault. To the north, the terrane extends only a short distance, as demonstrated by drill holes and inferred from the gravity and magnetic anomaly. To the east, the anomaly extends only to the coast of peninsular Florida and, in an interpretation of an offshore seismic reflection profile, Sheridan et al. (1981) found no evidence for the presence of this terrane off the Florida coast. As a result, it appears that the St. Lucie Metamorphic Complex encompasses only a relatively small area and may therefore be a fault-bounded block. An alternative possibility is that the metamorphic rocks represent a roof pendant in the proximal felsic igneous rocks (P. Mueller, 1993, personal communication).

The metamorphic grade of the assemblage is indicative of regional activity, which suggests that this small terrane represents an isolated fragment of a once larger unit (Bass, 1969). Another fragment of this larger unit may be present in the southeastern Gulf of Mexico. Metamorphic rock samples obtained during DSDP leg 77 on the Catoche Knoll are petrologically similar to the St. Lucie

Metamorphic Complex and are approximately the same age (Dallmeyer, 1984). Based on these similarities and because there are no other similar metamorphic terranes known in the Gulf of Mexico/Caribbean region, Schlager et al. (1984) have inferred the two to be cogenetic.

North Florida Rhyolite--region C. Overlying the Osceola Granite to the north and west is a terrane of slightly metamorphosed calc-alkaline rhyolitic to andesitic volcanic rocks. The upper surface of this terrane in northeastern Florida dips southeastward and ranges in depth from about 1180 m to about 1650 m (Smith, 1982). The calc-alkaline nature (Mueller and Porch, 1983) and trace element signatures (Heatherington et al., 1989) of samples from this terrane each suggest eruption in an ocean-continent convergent margin setting. In attempting to date two separate samples, one rhyolite and one andesite, Mueller and Porch (1983) identified disturbed 40Ar/39Ar release patterns from each--despite this, apparently concordant ages of 412 ± 15 Ma and 418 ± 9 Ma were obtained. Although the disturbed release patterns suggest these age determinations to be minima, stratigraphic relationships suggest a Late Precambrian to Early Paleozoic age for the terrane (Arden, 1974; Chowns and Williams, 1983).

Few structural inferences have been made about the North Florida Rhyolite. From a seismic reflection survey in the Florida panhandle, Arden (1974) distinguished faulting and gentle folds in the terrane. It is unclear whether these are ubiquitous Paleozoic features, as inferred by Thomas et al. (1989), or simply localized Triassic structures associated with the southwestward extension of

the South Georgia Rift, as suggested by Arden (1974) and Klitgord et al. (1984).

The sublateral extent of this terrane is uncertain. Although the distribution of drill holes intersecting rhyolite is generally coincident with an elongated negative gravity and magnetic anomaly (Figures 9 and 13--C), previous geophysical and drill hole studies suggest that the terrane continues northward under the Suwannee Basin terrane, described below, and extends into southern Georgia (Barnett, 1975; Wicker and Smith, 1978; Chowns and Williams, 1983). To the south, two drill holes intersecting rhyolite have been interpreted to indicate a subcrop of this terrane immediately south of the Osceola Granite (e.g., Chowns and Williams, 1983; Dallmeyer, 1987). Several undated rhyolitic samples have also been obtained from the south-central portion of the Floridan Plateau in the South Florida Basin; it has been suggested that these samples are either from horsts of this same felsic volcanic terrane (Thomas et al., 1989) or from part of a separate southerly Mesozoic bimodal suite (Barnett, 1975; Mueller and Porch, 1983). To the west, felsic basement rocks have been encountered in the Florida panhandle area; these rocks are undated, and have been variously correlated to the North Florida Rhyolite (Arden, 1974; Thomas et al.,1989), the Osceola Granite (Barnett, 1975), and to the Permian (?) granite of the Wiggins Arch in Mississippi (Smith, 1983).

Suwannee Basin--region D. Overlying the north Florida igneous rocks is the Suwannee Basin terrane, which has also been referred to as the North Florida Basin and the Tallahassee-Suwannee terrane (Arden, 1974; Barnett, 1975; Smith, 1982; Chowns and Williams,

1983; Thomas et al, 1989). This terrane extends northward into southern Georgia and westward at least to the Florida panhandle, as well as southwestward to the Middle Ground Arch in the north-central region of the plateau (Ball et al., 1983; Dobson and Buffler, 1991). The Suwannee Basin has been intersected by numerous drill holes at depths ranging from 720 m to 1730 m (Smith, 1982) and is composed of a massive Early Ordovician quartzitic sandstone overlain by intercalated Middle Ordovician to Middle Devonian sandstones and shales (Arden, 1974). The topographic high of the terrane, in the north-central portion of peninsular Florida, is an erosional remnant known as the Peninsular Arch.

The structure of the Suwannee Basin is somewhat better defined than that of the underlying North Florida Rhyolite, although the nature of the contact between the two is rather enigmatic. Arden (1974), from an interpretation of a seismic reflection profile, interpreted the contact to be a northeast-dipping, Middle to Late Paleozoic age thrust fault that emplaced the Suwannee Basin over the volcanics, while others (e.g., Thomas et al., 1989) have suggested the contact to be an unconformity. Although drilling into the Suwannee Basin terrane has never penetrated more than about 700 m, gravity modeling indicates that the eastern Suwannee Basin has a maximum thickness of about 2500 m (Wicker and Smith, 1978), while seismic reflection profiles suggest the western Suwannee Basin may be even thicker (Arden, 1974; Thomas et al., 1989).

Other structural details of the Suwannee Basin are better delineated. While the eastern portion appears to be relatively undeformed with a peneplained upper surface, Arden's seismic

profile and numerous drill holes have shown the western section to have been extensively faulted, mildly folded, and intruded by diabase during the Triassic evolution of the South Georgia Rift. This difference has prompted some workers to separate the Suwannee Basin into two distinct terranes, the East and West Suwannee Basins (e.g., Klitgord et al., 1983; Ball et al., 1988).

The relatively smooth potential-fields in the region occupied by the Suwannee Basin terrane are bisected by two linear NE-trending negative gravity anomalies separated by a distinct, northeast-trending negative magnetic anomaly and low-amplitude positive gravity anomaly. These extend from the northeasternmost Gulf of Mexico to the eastern Florida-Georgia border (Figures 11 and 13--feature D1). Based on an onshore, local, high resolution gravity study, Coleman and Stewart (1982) believed the Suwannee Basin sedimentary deposits to be underlain by two northeast-trending Paleozoic (?) troughs coinciding with these linear negative gravity anomalies. Offshore, however, Dobson and Buffler (1991) have interpreted basement faulting in a seismic reflection profile and the presence of Triassic red beds in proximal drill holes as indicative of a moderately-sized, northeast-trending Triassic rift basin extending at least to the northwest Florida coast and coinciding with the central positive gravity anomaly and the associated negative magnetic anomaly of feature D1. The absence of corresponding red beds in onshore drill holes suggests the possibility that feature D1, although relatively continuous, represents the cumulative effects of several structural features.

Although the boundary between the Suwannee Basin terrane and the superimposed Triassic South Georgia Rift is reasonably well constrained from drill hole data, it is likely that the Suwannee Basin extends northward and westward under the rift basin and for a significant distance beyond it. COCORP seismic reflection profiling (Nelson et al., 1985A) and gravity modeling (Lord et al., 1992) both indicate that the Suwannee Basin extends into southern Georgia along most of its border with Florida, although neither the nature nor the location of the northern or western boundaries of the terrane have been resolved.

Jay Fault--feature E-E[1]. A variety of evidence suggests the presence of a major crustal boundary, known as the Jay Fault, which may divide the Floridan Plateau crust. Northeastern Florida is generally characterized by northeast-southwest trending gravity and magnetic anomalies, while those in southwestern Florida are generally perpendicular to this trend (e.g., King, 1959; Oglesby et al., 1973; Smith, 1982). Although the boundary between these two trends is not well defined, it extends through the center of the plateau in a northwest-southeast direction, close to a landward extension of the trend of the Bahamas Fracture Zone.

Drill hole evidence and seismic reflection profiles suggest that the implied extension of the fracture zone also constitutes the boundaries of several features, including the South Georgia Rift, the north Florida igneous rocks, and the Suwannee Basin terrane (Barnett, 1975; Smith, 1983; Chowns and Williams, 1983; Ball et al., 1988; Dobson and Buffler, 1991). In addition, seismic reflection profiles along the eastern edge of the plateau (Sheridan et al., 1981)

and in the northeastern Gulf of Mexico (Dobson and Buffler, 1991) suggest normal faulting along this same trace. Consequently, the Jay Fault is generally considered to be a morphological extension of the Jurassic Bahamas Fracture Zone. The origin, character, and age of this extension, however, are unresolved (Barnett, 1975; Smith, 1982; Klitgord et al., 1984; Smith, 1993).

It has been suggested that the Jay Fault is a Jurassic left-lateral transform that served to connect spreading centers in the Atlantic and Gulf of Mexico, while bringing several disparate lithotectonic units into juxtaposition (Klitgord and Schouten, 1980; Smith, 1982; Klitgord et al., 1984). Using this model as a starting point, several authors (Smith, 1982; Chowns and Williams, 1983; Whitelaw and Smith, 1989) have hypothesized an extension of this proposed transform boundary across the Floridan Plateau and into Alabama, where it may merge with the Middle Mesozoic Gulf basin marginal fault zone (Smith, 1983; Klitgord et al., 1984).

Another possibility for the origin of the feature is that it is a right-lateral feature formed during the Late Paleozoic closure of the Iapetus Ocean (Smith et al., 1992; Smith, 1993). The premise of this model is that the Jay Fault originated in two stages. During the Paleozoic, the boundary was a right-lateral, strike-slip fault that served to accommodate differential motion within Gondwana during closure with Laurentia. Later, during Triassic and Jurassic extension, the boundary was reactivated as a normal fault. This would be consistent with the right-lateral fault model advanced by Barnett (1975), which was based on the seismic refraction profiles of Antoine and Harding (1965). Miller (1982), in a study of the structure of the

panhandle region, also suggested a right-lateral fault model, although in this model, the fault formed in response to north-south compressive stresses during the Jurassic.

Inherent in a third model for the nature of the lithotectonic boundary across Florida is the implication that the Jay Fault has never been subject to significant lateral motion (Heatherington et al., 1989; Heatherington and Mueller, 1991). Results of trace element analyses of basement rocks from north and south Florida exhibit similar patterns of high field strength element depletion and large ion lithophile element enrichment (Heatherington et al., 1989), as well as similar Nd model ages for the lithosphere from which these rocks were derived (Heatherington and Mueller, 1991). This suggests that the volcanic suites of north and south Florida may have been derived from a single contiguous underlying unit. It is possible, then, that this geophysically and lithologically inferred fault may not be a transform that juxtaposed two entirely disparate lithotectonic units, but rather that it is simply a normal fault zone that experienced little or no lateral movement (Heatherington and Mueller, 1991).

The linear nature of the Jay Fault is evident on the depth-to-basement and upward-continued Bouguer anomaly maps (Figures 10 and 14--E-E^{1}). The upward-continued Bouguer anomaly map strongly suggests that the fault acts as boundaries for the Osceola Granite (A), the St. Lucie Metamorphic Complex (B), the South Georgia Rift (F), the South Florida Basin (L), and several other Jurassic structural features (H, I, J), which are described below. Thus, not only

is the Jay Fault linear, but apparently continuous across the Floridan Plateau as well.

Along the southeastern edge of the plateau, Sheridan's (1981) seismic reflection profile clearly shows a series of faults with varying amounts of horizontal offset along the proposed trace of the Jay Fault. Hence, the Jay Fault is more accurately described as a zone of faulting, rather than as a single fault. An abrupt southward increase in depth-to-basement marks the zone along most of its length. An exception to this is in the northwestern part of the plateau where the South Georgia Rift extension intersects the zone. At this point, a seismic reflection profile (Dobson and Buffler, 1991) indicates the presence of a single northeastward-dipping master fault. Thus, although the Jay Fault zone appears to be continuous and linear, the nature of the Mesozoic faulting changes along strike.

Mesozoic Features of the Plateau Basement

The Floridan Plateau basement is characterized by a variety of Mesozoic structural features. Lithic accumulations associated with these features (i.e., red beds, hypabyssal rocks, etc.) often obscure the pre-Mesozoic units of the underlying crust and, as a result, the pre-Mesozoic nature of the basement under these features is largely unresolved. While the general locations of Mesozoic features on the plateau basement are reasonably well established, specific structural details and subaerial boundaries are poorly constrained.

Part of a large Triassic continental rift complex extends onto the plateau along its northern boundary (McBride, 1991). The western half of the plateau is dominated by an alternating series of

northeast-striking Jurassic basins and ridges. This series extends to southern peninsular Florida, where a large Triassic-Jurassic basin occupies the southern third of the peninsular basement (Klitgord et al., 1984).

South Georgia Rift--region F. Underlying the north-central portion of the plateau is a 95 km wide, northeast-trending section of the Early Mesozoic South Georgia Rift. The South Georgia Rift is a large, complex graben system extending from the Florida panhandle area to eastern Georgia (Daniels et al., 1983; McBride, 1991). The section in Florida overlies the western block-faulted edge of the Suwannee Basin terrane (Smith, 1982) and has been previously referred to as the Tallahassee Graben (Smith, 1983) and the Southwest Georgia Embayment (Barnett, 1975; Miller, 1982). The rift is filled with arkosic sandstones and mafic igneous rocks with a maximum thickness of about 1800 m in Florida (Arden, 1974) and it has been pervasively intruded by diabase sills (Barnett, 1975; Chowns and Williams, 1983; Smith, 1983). Milton and Grasty (1969) acquired three K-Ar ages for samples of diabase sills from northern Florida. Although these ages are now generally considered to be suspect, they were found to range from about 180 to 200 Ma.

The onshore boundaries of the South Georgia Rift are reasonably well constrained from the presence of red beds and associated hypabyssal rocks encountered in deep drill holes. A circular negative gravity anomaly with a diameter of about 50 km (Figure 14--F) generally marks the South Georgia Rift extension, although this anomaly may alternatively be attributable to

accumulations of low density salt in the Jurassic Apalachicola Embayment, which overlies the South Georgia Rift in this area.

The north-central Floridan extension of the Triassic-Early Jurassic South Georgia Rift system is a moderately complex feature. The presence of short-wavelength gravity and magnetic anomalies in the area of the rift (Figures 11 and 15--F) may indicate it to be comprised of an assemblage of secondary horst and graben structures (Barnett, 1975; Smith, 1983). Limited seismic reflection profiling shows extensive normal faulting in the rift floor and the surrounding area; however, no large secondary horsts have been definitively detected (Arden, 1974; Dobson and Buffler, 1991).

Because there are few seismic reflection profiles in the area and, as shown in Figure 14, the long-wavelength potential-field signatures associated with the rift have relatively low gradients, the lateral boundaries of the rift extension are not definitively mapped or characterized. Ball et al. (1988), in a seismic reflection profile just off the coast of the Floridan panhandle, interpreted a northeast-dipping master fault with about 1400 m of throw to mark its southwestern terminal boundary. Subsequent reflection work has shown the offshore extension of the rift system to consist of two separate grabens, at least one of which probably extends to the southwest as far as the Jay Fault zone (Dobson and Buffler, 1991).

Apalachicola Embayment/Apalachicola Basin--regions F, G. Extending from northwest to southeast across the Floridan Plateau are an alternating series of northeast-striking, Late Triassic to Late Jurassic basement horsts and grabens, a number of which appear to be bounded by the Jay Fault zone (Figure 10--E-E^1). These include

the Apalachicola (or Southwest Georgia) Embayment (F) and the Middle Ground Arch (H), a basement high that may extend undisturbed across the Jay Fault zone. These are located to the northeast of the Jay Fault zone and are part of a series that extends northwestward and includes the Chattahochee Arch, the Covington Embayment, the Conecuh Arch and the Wilcox Embayment, all of which lie out of this study area (e.g., Miller, 1982; Mitchell-Tapping, 1982; Smith, 1983).

On the southwestern side of the Jay Fault zone are the Apalachicola Basin (G), also known as the Northeast Gulf Basin, and the Tampa Basin (I), also known as the St. Petersburg Basin. These are separated by the Middle Ground Arch (H). Continuing to the southeast, the Sarasota Arch (J), also known as the Pinellas Arch, separates the Tampa Basin (I) from the South Florida Basin (L) (e.g., Klitgord et al., 1984; Ball et al., 1988; Winker and Buffler, 1988; Dobson, 1990; Dobson and Buffler, 1991). As shown in Figure 16, there have been significant variations between previous publications with regard to the locations, sizes, and spatial relationships of these various Jurassic features.

The Apalachicola Embayment (F), which is bounded along its northwestern edge by the Chattahoochee Arch, is a Jurassic basement trough overlying the Triassic South Georgia Rift. On the basis of drill holes and electric logs, Mitchell-Tapping (1982) modeled the Apalachicola Embayment as a graben flanked by two peripheral master faults and encompassing a basement high near its southwestern border. With the possible exception of the previously

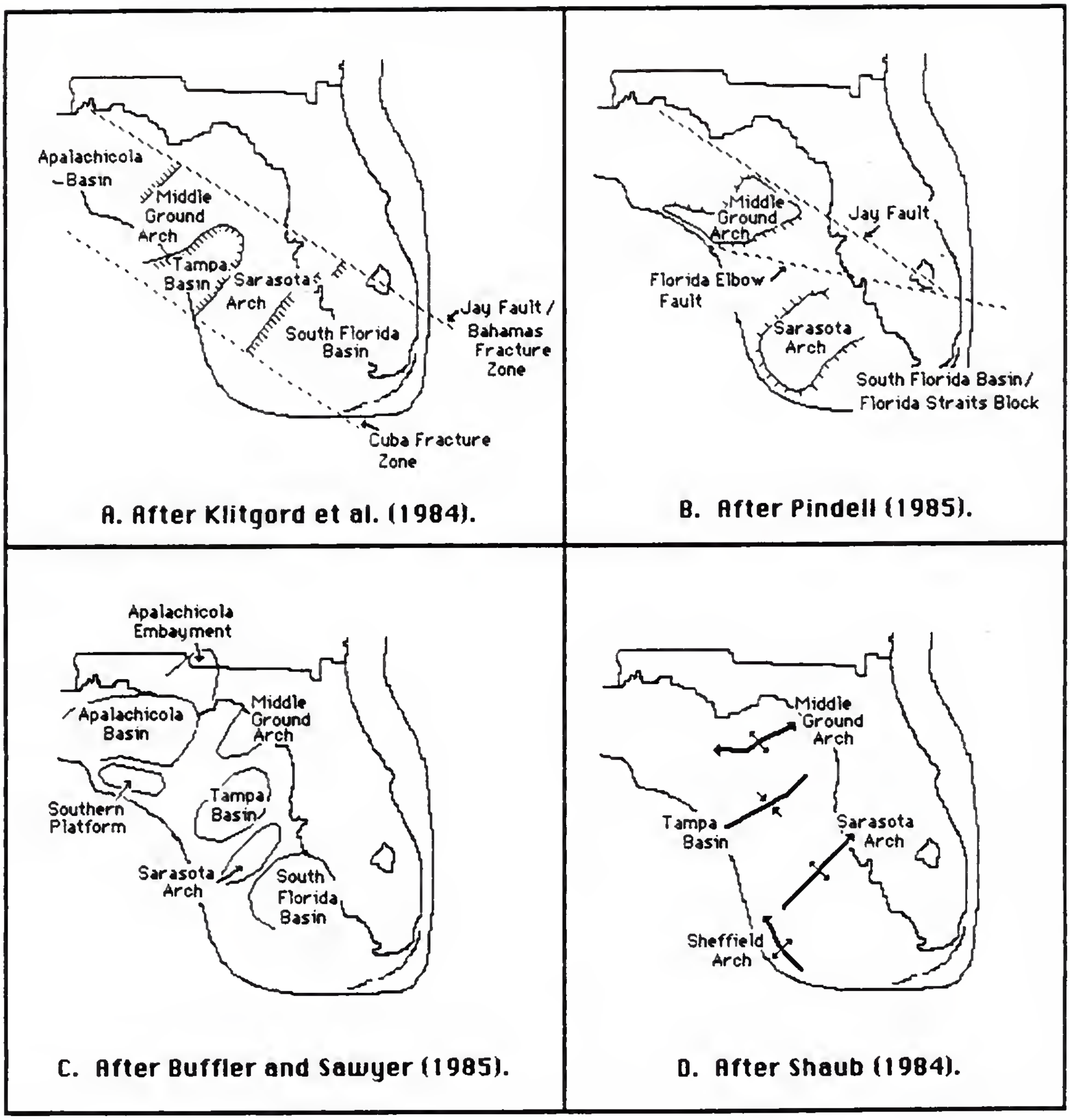


Figure 16. Various previously published configurations for the Mesozoic structure of the southern and western Floridan Plateau basement.

discussed circular negative gravity anomaly, there is no definitive potential-field signature attributable to the Apalachicola Embayment.

The Apalachicola Embayment is contiguous with, and essentially indistinguishable from, the Apalachicola Basin,except that the two are separated by a prominent basement hingeline at the apparent trace of the Jay Fault zone and the Apalachicola basin is characterized by a much greater depth-to-basement. Southwest of the hingeline, dipping intrabasement reflections suggest the presence of Paleozoic strata with a synclinal structure underlying the Apalachicola Basin (Dobson, 1990; Dobson and Buffler, 1991). The eastern section of the basin in the study area is marked by a moderate amplitude positive gravity and magnetic anomaly (G). The basin extends southwestward to the plateau escarpment and may reach a basement depth of 12 km (Buffler and Sawyer, 1985; Buffler, 1989). The eastern margin of the basin is marked by a major bounding fault with a throw of at least 1000 m (Ball et al., 1988). This fault separates the Apalachicola Basin from the Middle Ground Arch.

Middle Ground Arch--region H. Extending across the Jay Fault zone, adjacent to the Apalachicola Basin, is the Middle Ground Arch. This is a broad, topographically positive feature that extends from the southwestern flank of the Peninsular Arch westward to the edge of the plateau (Figure 10--H). The crest of this ridge dips generally westward and ranges in depth from about 1500 m under peninsular Florida to about 6000 m at the Florida Escarpment out of the study area (Dobson and Buffler, 1991). As a consequence of a narrow saddle in the Middle Ground Arch at the divide between the

Apalachicola and Tampa Basins immediately west of the Jay Fault zone, the arch has been classified by some as two separate features--the Middle Ground Arch to the east and the Southern (or DeSoto) Platform to the west (Winker and Buffler, 1988; Dobson, 1990; Dobson and Buffler, 1991).

The Middle Ground Arch is marked by one of the northeast-trending, long-wavelength, low amplitude negative gravity anomalies (Figure 14--H) previously mentioned as flanking feature D1. Although there are few short-wavelength features in the region, seismic reflection profiles have shown the crest of the Middle Ground Arch to have been moderately faulted. As suggested by stratigraphic perturbations, these faults have horizontal throws on the order of 100 m and became inactive after the Late Jurassic (Ball et al., 1988; Dobson, 1990). In addition, graben structures and fill associated with the South Georgia Rift extend along the crest of the northeastern end of the Middle Ground Arch from peninsular Florida to the Jay Fault zone (Dobson and Buffler, 1991). An intrabasement igneous intrusive body, possibly Mesozoic in age, has been identified on seismic reflection profiles and is marked by an oblong low amplitude negative gravity anomaly (Figure 15--feature H1) (Ball et al., 1988). Near the southeastern flank of the Middle Ground Arch, a single drill hole intersecting Paleozoic siltstones (Ball et al., 1988) signifies a possible westward extension of the Suwannee Basin terrane.

Martin (1978) suggested that the Middle Ground Arch is simply a residual feature formed by more rapid rates of subsidence to the north and south; however, the subsequent recognition of the northwestern bounding fault between the arch and the Apalachicola

Basin implies a significant degree of structural control. The single seismic reflection line extending across the southeastern boundary of the arch, on the other hand, does not show any analogous faulting (Ball et al., 1988). In addition, the Bouguer anomaly gradient across the strike of this southeastern boundary is uniform and relatively low (Figure 12). These observations suggest the Tampa Basin-Middle Ground Arch margin to be a broad transition zone with little structural control, which reinforces Martin's proposal of formation by differential subsidence for this particular boundary.

Tampa Basin--region I. Southeast of the Middle Ground Arch is the Tampa Basin, which is also known as the Florida Elbow Basin (Pindell, 1985). It is essentially an analogue to, and coeval with, the Apalachicola Basin. The Tampa Basin extends updip northeastward from the western edge of the plateau although, unlike most the other Jurassic features in this series, it has not been previously mapped as extending eastward as far as the Jay Fault zone (e.g., Klitgord et al., 1984; Buffler, 1989). It reaches a depth-to-basement of at least 5500 m (Figure 10--I) and Dobson and Buffler (1991) have modeled it to be significantly deeper (greater than 9000 m).

Seismic reflection profiles are characterized by dipping intrabasement reflections in the basin that, as in the basement of the Apalachicola Basin, imply an underlying extensively faulted Paleozoic synclinal structure (Ball et al., 1988; Dobson, 1990). None of the three offshore wells intersecting basement in the Tampa Basin, however, have demonstrated the accumulation of any Paleozoic sediments (Figure 9). Rather, the two westernmost wells bottomed in granite, while the third bottomed in a rhyolite porphory

intercalated with Jurassic diabase (Dobson and Buffler, 1991). In addition, some of this faulting perturbed the Cretaceous sediments immediately overlying these igneous rocks. Thus, it is likely that at least some of the basement faulting and structure originated during the Jurassic evolution of the basin, rather than during the Paleozoic.

The Bouguer anomaly signature of the Tampa Basin is quite distinct (Figure 14--I). It is marked by a 50 mgal long-wavelength positive gravity anomaly. This positive anomaly averages about 160 km wide and 275 km long, suggesting that the Tampa Basin is significantly larger than shown on previous basement maps; however, a corresponding positive magnetic anomaly appears to be somewhat smaller (Figure 11--I). As discussed above, the northwestern boundary of the basin is probably a sloping margin. That margin appears to crest approximately 40 km south of the northernmost expression of the gravity anomaly, although shallow dip interpretations are difficult from the available seismic reflection profiles.

Pindell (1985) has speculated that a large strike-slip fault, the Florida Elbow Fault, extends northwestward from the Jay Fault zone, across the Tampa Basin, and into the northeastern Gulf of Mexico. Although there is no gravity or seismic evidence for such a fault, the steep eastward-striking magnetic gradient which bisects the northern half of the basin may be the result of a structure along that trend. The relative absence of short-wavelength gravity anomalies implies little intrabasinal structure (Figure 15--I), although there is some short-wavelength variability in the magnetic field immediately west of the no data zone (Figure 11--I). Two adjoining 25 km

diameter moderate amplitude negative gravity anomalies with corresponding positive magnetic anomalies may indicate the presence of mid-crustal intrusive bodies similar to that under the Middle Ground Arch (Figures 11 and 15--feature I1).

The northeastern boundary of the Tampa Basin, as suggested by the positive gravity anomaly, appears to correspond extremely well with the presumed trace of the Jay Fault zone (Figure 14). This places the easternmost section of the Tampa Basin under western peninsular Florida and shifts the boundary significantly more northeastward than had been previously modeled, although Ball et al. (1988) identified a basement monocline only 30 km off the west coast of Florida that was suggested to be the boundary. In addition to the positive gravity anomaly, the presence of Jurassic diabase in several drill holes in the same area of western peninsular Florida (Figure 9) and a corresponding positive magnetic anomaly (Figure 11) are also suggestive of a northeastward extension of the basin as far as the Jay Fault zone.

The southeastern boundary of the basin, which separates it from the Sarasota Arch, is better constrained with respect to location. Along this boundary, both of the potential-field gradients are relatively high, which is suggestive of a morphologically distinct feature. Although not confirmed by seismic data, stratigraphic correlations from well logs also suggest the presence of a large down-to-the-north fault or series of faults along this boundary; this fault could have a throw of as much as 2000 m (Ball et al, 1988).

Sarasota Arch--region I. The Sarasota Arch is a 150 km wide, 350 km long, topographically positive feature that separates the

Tampa Basin and the South Florida Basin. It extends from the Jay Fault zone under peninsular Florida westward possibly to the edge of the Florida Escarpment (Figure 10--J), although Klitgord et al. (1984) have suggested that the arch may be truncated by an extension of the Cuba Fracture Zone just east of the escarpment. The depth-to-basement of the Sarasota Arch averages 4 km and there is little evidence of any significant dip along the crest. There have been four drill holes intersecting basement on the Sarasota Arch--three bottomed in granitic rocks and one intersected diabase (Figure 9).

Although seismic profiles in the southern quarter of the Floridan Plateau tend to be poor quality as a consequence of the depth and the attenuation of seismic energy by the overlying karstic limestone, a number of vertical faults have been observed on seismic profiles crossing the Sarasota Arch (Shaub, 1984; Ball et al., 1988). These faults are small, with throws on the order of 10s of meters, and, as suggested by perturbations in the overburden, became inactive by the Early Cretaceous.

Klitgord et al. (1984) interpreted a northeast-trending zone of circular gravity and magnetic anomalies along the northwest edge of the Sarasota Arch to be the result of a series of shallow intrabasement intrusive bodies. Although several short-wavelength circular negative gravity anomalies exist in this area (Figure 13--region J), not all of these correlate well with the circular magnetic anomalies (Figure 11--region J). Therefore, while two or three of the anomalies, particularly the concomitant circular negative gravity anomalies and positive magnetic features similar to H1 and I1 above, may be caused by scattered shallow to mid-crustal igneous

intrusions, a linear chain spatially associated with the Sarasota Arch seems improbable.

The Sarasota Arch is marked by a distinct long-wavelength negative gravity anomaly (Figure 14--J), although there seems to be no particular associated magnetic signature (Figure 11). As described above, the northwestern boundary of this negative anomaly correlates well with the large bounding fault inferred by Ball et al. (1988). Although the anomaly appears to be partially truncated near its northeastern boundary, it generally extends southwestward from the region of the Jay Fault. The southwestern boundary of the negative anomaly could be interpreted to occur slightly east of the escarpment; however, a seismic reflection profile along the crest of the Sarasota Arch (Ball et al., 1988) shows no evidence for truncation at an extension of the Cuba Fracture Zone. As a result, it is likely that the southwestern boundary of the arch is coincident with the Florida Escarpment.

The southeastern boundary of the Sarasota Arch, as interpreted from a seismic reflection profile near the escarpment, is a southeastward-dipping, relatively steep, block faulted margin (Shaub, 1984) that corresponds to the boundary of the negative gravity anomaly. However, this gravity boundary is not continuous. As discussed below, a 60 km wide negative gravity anomaly extends southeastward from the boundary (Figure 14 --feature L4) and is consistent with the probable presence of a large basement horst within the South Florida Basin.

Sheffield Arch--region K. From local seismic reflection and Ocean Bottom Seismometer (OBS) refraction profiles, Shaub (1984)

recognized a possible basement high along the Florida Escarpment extending southeastward from the Sarasota Arch. This high, the Sheffield Arch, was identified from a limited number of profiles with no deep well control and is, therefore, not well characterized.

There is a positive gravity anomaly oriented generally along the axis of this proposed arch (Figures 14 and 15 --K). This positive anomaly is approximately 180 km long and 120 km wide. It has no concomitant magnetic signature. Although the positive gravity anomaly could be the result of a morphologically positive feature such as the Sheffield Arch, all of the other positive basement features of the Floridan Plateau have been characterized by negative gravity anomalies. Consequently, the characterization of a large, continuous basement high in this area is unresolved.

South Florida Basin--region L. Underlying southern peninsular Florida is a Triassic-Jurassic structural feature known as the South Florida Basin. Based on a series of two-dimensional gravity profiles, Wicker and Smith (1978) determined that the basin ranges in depth from about 3000 m in south-central peninsular Florida to more than 5500 m at the southern edge of the peninsula. The basin is generally considered to underlie much of the southern portion of the Floridan Plateau and to extend to its southern and eastern edges (e.g., Barnett, 1975; Smith, 1983; Klitgord et al., 1984). The western extent of the basin and the presence of any significant intrabasinal structures are unresolved.

The South Florida Basin is generally coincident with a lithologic terrane characterized by the presence of both basalt and rhyolite. While this terrane is usually considered to be a bimodal suite of

Triassic alkali basalts and rhyolites (Barnett, 1975; Mueller and Porch, 1983; Heatherington and Mueller, 1991), it has been suggested that the occurrences of rhyolite represent horsts of an underlying southerly extension of the Late Precambrian-Cambrian North Florida Rhyolite (Thomas et al., 1989). Isotopic dating of the rhyolites (Milton and Grasty, 1969; Barnett, 1975) and the basalts (Milton, 1972; Mueller and Porch, 1983) suggest that the two are coeval, with ages of about 180 Ma. This supports the model that the basalts and rhyolites comprise a Mesozoic bimodal suite and almost certainly discounts the premise that the rhyolites in the region of the South Florida Basin are part of the North Florida Rhyolite.

There are only a few drill holes intersecting basement within the South Florida Basin and all of these are in southwestern and south-central peninsular Florida (Figure 9). In addition, there is only one published seismic reflection profile of the basement in the basin (Figure 2). As a result, the basement model for this area is necessarily based almost exclusively on potential-field data and is, therefore, rather speculative.

The northeastern boundary of the South Florida Basin is the Jay Fault zone. In their seismic reflection profile along the eastern edge of the Floridan Plateau, Sheridan et al. (1981) found this boundary to be a large, down-to-the-south, normal fault with an associated series of smaller faults at the landward extension of the Bahamas Fracture Zone. The boundary is marked by a northwest-trending zone of steep gravity and magnetic gradients (Figures 11 and 14--E-E^{1}). As described above, the northwestern boundary of the basin area is the southeastward-dipping faulted margin of the Sarasota Arch. The

southern margins of the South Florida Basin are not morphologically well defined; however, the basin is considered to extend at least as far as the Florida Escarpment.

Although the entire area bounded by the Jay Fault zone, the Sarasota Arch, and the Florida Escarpment is commonly considered to be a singular basin, there are four or five (depending on whether feature K is included) individual long-wavelength potential-field features within these bounds (Figures 11 and 14--L1-L4). For example, the northeastern corner of this region is marked by an oblong positive gravity and magnetic anomaly oriented along the Jay Fault zone (L1). Immediately southeast of this feature is a similarly oriented negative gravity and magnetic anomaly (L2) which, in turn, is separated from a second negative gravity anomaly (L3) by a second positive gravity anomaly (L4). This long-wavelength variability and the shapes of these features suggest the probability of several northwest-southeast oriented basins within the area traditionally considered to be the South Florida Basin.

All of the South Florida Basin area drill holes which have successfully intersected basement have been located proximal to a negative gravity and magnetic anomaly, specifically, feature L2. This suggests that the anomaly may mark a region characterized by a relatively shallow basement. In addition, the southern end of Sheridan's reflection profile, near the southeastern corner of the plateau, was located on a positive gravity and magnetic anomaly and indicated an anomalously high depth-to-basement. Consequently, consistent with the other features of the Floridan Plateau except possibly the Sheffield Arch, it appears that the long-wavelength

gravity and magnetic anomalies within the South Florida Basin denote high depth-to-basement areas, while the negative gravity and magnetic anomalies are characteristic of shallow basement arches.

Blake Plateau Basin--feature M. Along the northeastern edge of the Floridan Plateau is an area that, as suggested by a series of seismic refraction profiles (Sheridan et al., 1966), is characterized by an increase in depth-to-basement (Figure 10--M). This feature may represent a shallow salient of the Blake Plateau Basin, which is the southernmost of the four major Jurassic-Early Cretaceous basins of the eastern United States continental margin (e.g., Grow and Sheridan, 1982; Dillon et al., 1985). There is no particular gravity signature attributable to this salient. The western boundary of the main body of the Blake Plateau Basin is located just east of the eastern continental margin of the Floridan Plateau, slightly out of this study area. Although the data are limited, there is no evidence that the salient is fault-bounded. Rather, it appears to have formed simply by differential subsidence.

Cenozoic Structural Features of the Floridan Plateau

There are only a few reports of Tertiary structural features of tectonic origin on the Floridan Plateau. These include small faults resulting from halokinesis off the panhandle of peninsular Florida (e.g., Addy and Buffler, 1984; Ball et al., 1988), as well as slump faults and related features near the western Florida escarpment (e.g., Mullins et al., 1988; Corso et al., 1989). In addition, there have been a few purported Tertiary features that were inferred to have had

tectonic origins; however, in each of these cases, subsequent workers have failed to confirm these origins.

The most predominant of these reported features include several surficial anticlinal and synclinal structures in northwestern peninsular Florida and southwestern Georgia. Patterson and Herrick (1971) summarized the reports of these features, which conflicted with respect to locations and descriptions in many cases, and concluded that there is no evidence to support the presence of any surficial structural feature in this area, with one possible exception. This exception is a small dome in southwestern Georgia, slightly outside of this study area, known as the Gordon Anticline. The other reported features were attributed to the differential erosion and dissolution of the near-surface Tertiary carbonates.

A Tertiary feature that is regularly mentioned in the literature is the Ocala Uplift, a reported anticlinal structure in central peninsular Florida. As in the previous instances, a tectonic origin for this feature was dismissed by Winston (1976), who attributed the apparent anticlinal structure of the surficial carbonates as having been caused by differential erosion and dissolution.

The only other purported Tertiary feature is the Bronson Graben, described as a small northwest-trending structure in north-central peninsular Florida with an associated series of surficial normal faults paralleling it. This was proposed by Vernon (1951) on the basis of lineations in aerial photographs and discrepancies in drill hole logs. Subsequently, this report was utilized by Zoback and Zoback (1980) to suggest a northeast-southwest least horizontal principal stress direction for the Floridan Plateau and by Prowell

(1989) to extend Appalachian fault provinces along the length of the plateau. Since 1951, there has been no field recognition of these features, and it is unlikely that Vernon's observations are indicative of lithospheric movement during the Tertiary. It appears, then, that with the possible exception of the Gordon Anticline, there is no evidence for any Tertiary structure on the Floridan Plateau attributable to regional tectonic stress.

Summary

A compiled map of the pre-Mesozoic lithotectonic terranes of the Florida Plateau basement is shown in Figure 17. In northeastern peninsular Florida, southern Georgia, and the Florida Panhandle, the subcrops of Precambrian and Paleozoic rocks apparently represent isolated pieces of more extensive terranes that were fragmented during the collision and subsequent separation of Laurentia and Gondwana. Although these fragments were not significantly metamorphosed during this process, there is evidence allowing the suggestion of thrust faulting, block faulting, and faulted contacts. Potential-field gradients, lithologic contrasts, and the limited existing seismic reflection data suggest that all of the contacts between these pre-Mesozoic terranes may be faulted, with the possible exception of the boundary between the Osceola Granite and the North Florida Rhyolite.

Figure 18 represents a compilation of the Mesozoic structural features of the Floridan Plateau basement. The Jay Fault zone acts as a boundary for many of the lithotectonic features of the Floridan Plateau basement and is the predominant structural feature of the

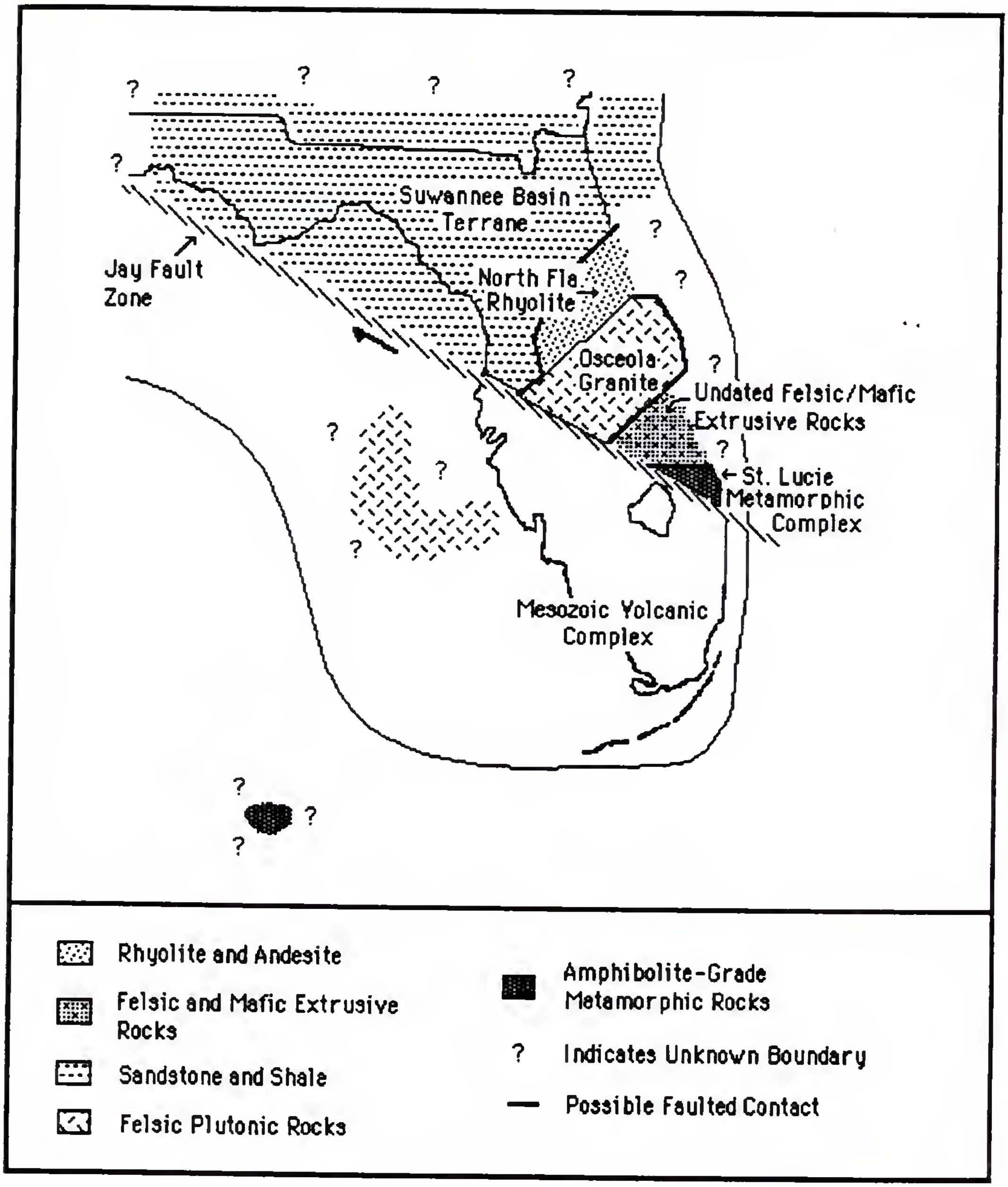


Figure 17. Pre-Mesozoic lithotectonic features of the Floridan Plateau basement.

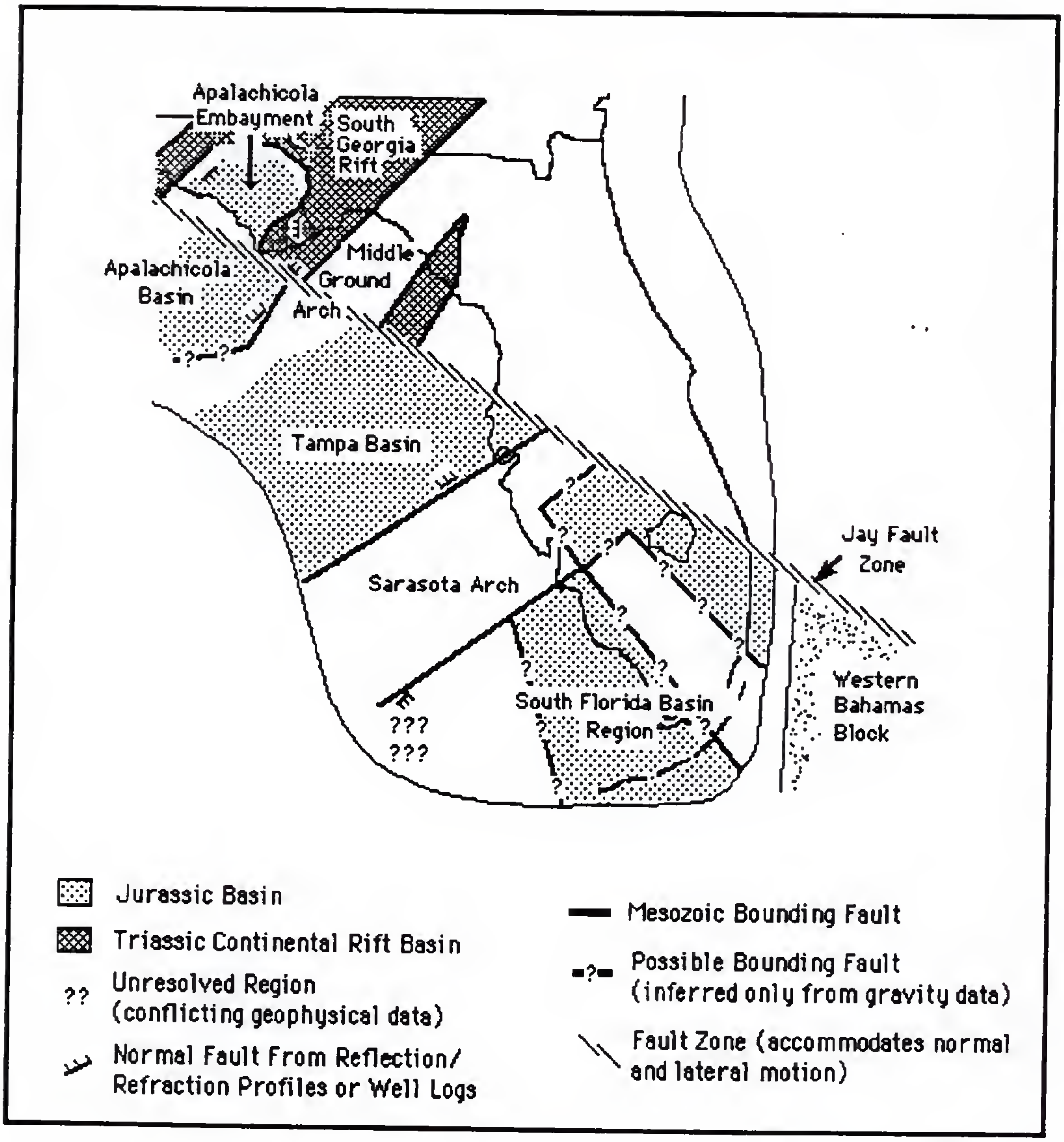


Figure 18. Mesozoic structural features of the Floridan Plateau basement. South Georgia Rift after Dobson and Buffler (1991) and McBride (1991). Apalachicola Embayment from Mitchell-Tapping (1982).

plateau. Although the linear nature of the fault zone suggests that it originated as a strike-slip fault, the present structure of the zone is independently determined by each of the bordering Mesozoic extensional features and consequently changes along strike. In the southeastern region of the plateau, the fault zone primarily consists of a series of southwestward-dipping normal faults. To the northwest along much of its length, the zone alternates between accommodating significant vertical offsets at southwestward-dipping Jurassic basin boundaries and having little or no vertical offset where intersected by basement arches. In the northwest, the zone changes to accommodate the northeastward-dipping normal bounding faults of the South Georgia Rift.

The southwestward extension of the South Georgia Rift into Florida resulted in block faulting in the western Suwannee Basin terrane. Although there is some suggestion of intrarift horst and graben formation, neither these structures nor the lateral master bounding faults of the rift extension have been definitively located or characterized. There is a small ancillary rift basin (or basins) southeast of the main rift. As mentioned above, the southwestern boundary of the South Georgia Rift is a large northeastward-dipping normal fault at the Jay Fault zone.

Overlying the South Georgia Rift in this area is the Jurassic Apalachicola Embayment, which, as suggested in previous studies, may also be bordered by lateral master faults. The Apalachicola Embayment extends southwestward across a basement hingeline at the trace of the Jay Fault zone. It merges with the deeper Apalachicola Basin, which is one of a series of northeast-striking

extensional basins bordering the southwestern side of the Jay Fault zone.

These basins, the Apalachicola Basin, the Tampa Basin, and the South Florida Basin, are separated by two wide basement ridges, the Middle Ground Arch and the Sarasota Arch. Each of the basins, with the probable exception of the northwestern edge of the Tampa Basin, is fault-bounded along its lateral boundaries. In addition, it is likely that each extends from the Jay Fault zone southwestward at least as far as the Florida Escarpment. Although there is little corroborating seismic reflection data for the South Florida Basin, potential-field signatures suggest the probability that this area is underlain by several isolated basins, rather than being a singular feature. A basement low under the northeast edge of the Floridan Plateau is interpreted to be a subsided landward salient of the Jurassic Blake Plateau Basin.

With the exception of gravity-induced slump features near the Floridan Escarpment and small faults in the northeastern Gulf produced by halokinesis, there is no evidence of any Tertiary structural feature on the Floridan Plateau. There may be a small anticlinal structure, the Gordon Anticline, in southwestern Georgia just north of this study area.

CHAPTER 3
TECTONIC EVOLUTION OF THE FLORIDAN PLATEAU

Introduction

As a consequence of the depth of burial of the Floridan Plateau basement and the lithotectonic complexity of the region, past interpretations of tectonic history have necessarily been based on an inadequate knowledge of basement structure. The intention in this chapter is to provide a reinterpretation of the tectonic history of the Floridan Plateau within the context of the new interpretations of lithologic and structural relationships presented in Chapter 2 and to incorporate the findings of recently published geochemical, geophysical, and tectonic studies into this interpretation.

Regional Tectonic History

Pre-Mesozoic

Tectonic reconstructions for the continental block(s) underlying the Floridan Plateau and the adjacent Bahamas Platform are based primarily on sparse information from deep drill hole samples and, as a consequence, the origin of these blocks has been the subject of some debate. The Suwannee Basin terrane and, by association, the Osceola Granite and St. Lucie Metamorphic Complex, have been shown to be allochthonous with respect to North America. Several investigators have found the Paleozoic Suwannee Basin fossil

assemblages to have Gondwanan affinities (e.g., Cramer, 1971; Pojeta et al., 1976). In addition, paleomagnetic data and ages of detrital zircons (Opdyke et al., 1987; Mueller et el., 1993) are also inconsistent with a Laurentian origin for this terrane. As a result, a correlation between these terranes and Gondwana prior to the Alleghenian closure of the Iapetus Ocean has been reasonably well established; however, the specific position of the Floridan Plateau with respect to Gondwana during the Paleozoic has not been definitively established.

A number of investigations have suggested that the pre-Mesozoic basement terranes of the northeastern Floridan Plateau originated along Africa's western margin near Senegal. These investigations include continental reconstructions (Bullard et al., 1965; Wilson, 1966; Dietz et al., 1970; LePichon and Fox, 1971; Pindell and Dewey, 1982; Klitgord et al., 1983; Roussell and Liger, 1983; Van Siclen, 1984; Pindell, 1985; Venkatakrishnan and Culver, 1988), paleontological analyses from Florida and Africa (Cramer, 1971, 1973; Pojeta et al., 1976), comparisons of isotopic abundances and ages (Dallmeyer, 1987, 1988; Dallmeyer et al., 1987; Heatherington et al., 1993), paleomagnetic data (Van der Voo et al., 1976; Opdyke et al., 1987), and stratigraphic correlations between Florida and west Africa (Smith, 1982; Chowns and Williams, 1983). Although a proposed tectonic history for Florida based on any one of these lines of evidence would be inconclusive, the cumulative effect of these independent observations is to provide strong support for a west African origin.

There are specific units in western Africa that can be correlated to their apparent counterparts underlying the Floridan Plateau. These units provide the sole record of the pre-Mesozoic tectonic history of the Floridan Plateau. The extensive North Florida Rhyolite of north Florida and south Georgia may be correlated to similar felsic volcanic rocks which are present throughout the western margin of Africa (Dillon and Sougy, 1974; Dallmeyer, 1987; Dallmeyer and Villeneuve, 1987; Heatherington et al., 1993). Geochemical analyses of the Florida suite suggest emplacement in a convergent plate margin setting, with an ocean-continent subduction environment being the most likely setting (Mueller and Porch, 1983).

The St. Lucie Metamorphic Complex has been correlated to units of the central Rockelide Orogen in Guinea, proximal to the Bové Basin (Chowns and Williams, 1983; Dallmeyer and Villeneuve, 1987). In addition to similarities in petrology and degree of metamorphism, both of these metamorphic units appear to have been affected by an extensive thermotectonic event, Pan-African II, that occurred along the northwestern margin of Gondwana about 550 Ma ago (Dallmeyer and Villeneuve, 1987). In addition, there is no evidence that the St. Lucie Metamorphic Complex was thermally affected by the subsequent Caledonian or Hercynian orogenies. This is consistent with a central Rockelide origin for the complex, but not with a more northerly origin, where the adjacent Mauritanides were strongly deformed during the later orogenies (Roussel et al., 1984), nor with a more southerly origin, where Pan-Africa II had little effect (Williams and Culver, 1982).

There are a number of similarities that support the correlation of the Osceola Granitoid Complex of east central Florida with the Coya Granite of Senegal, which is exposed in the northern Rockelides. Both are post-tectonic, Early Paleozoic plutons with similar petrographic and petrologic characteristics (Dallmeyer et al., 1987). These similarities, as well as numerous continental reconstructions, suggest that during the Early Paleozoic, the Osceola and Coya Granites were likely to have formed as part of the series of granitoids emplaced along Gondwana's northwestern margin during Pan-African II orogenies (Dillon and Sougy, 1974; Dallmeyer et al., 1987).

The Suwannee Basin Complex of north-central Florida was deposited in an Early Paleozoic sedimentary basin. The lower portion of the sampled sequence of this complex consists of quartz sandstones overlain by graptolite-bearing black shales, which are indicative of a restricted marine environment. Based largely on stratigraphic and paleontological similarities, the Suwannee Basin was correlated by a number of workers to the Bové Basin of western Guinea (Cramer, 1971, 1973; Pojeta et al., 1976; Smith, 1982; Chowns and Williams, 1983; Venkatakrishnan and Culver, 1988). Subsequently, a paleomagnetically determined Lower Ordovician paleolatitude of 49 degrees south (Opdyke et al., 1987) and a comparison of plateau ages for muscovite (ca. 505 Ma) from both basins (Dallmeyer, 1987) have provided further support for this correlation. These deposits probably represent the disjointed remnants of a single, extensive restricted basin that existed along the northwestern margin of Gondwana during the Early to Middle Paleozoic.

Although the present day basal contact of the Suwannee Basin terrane is likely to be a simple unconformity, there is some evidence to suggest that it may instead be a northward-dipping thrust fault. Although the Suwannee Basin has been only mildly metamorphosed, seismic reflection profiles suggest the presence of low angle faulting within the terrane (Arden, 1992, personal communication) and the basal contact has the appearance of a ramped thrust fault (Arden, 1974). In addition, thrust faults are common in the central Rockelides, which are in close proximity to the Bové Basin (e.g., Williams and Culver, 1982).

Smith (1993) has postulated that the pre-Mesozoic terranes of the plateau basement, including the Suwannee Basin, the North Florida Rhyolite, the Osceola Granite, and the St. Lucie Metamorphic Complex, were fragmented and repositioned to their present day configurations during the late stages of Alleghenian closure. In this scenario, fragments of these Gondwanan terranes were moved laterally into their relative positions, with separate fragments being translocated into eastern Florida, southeastern Georgia, and northwestern Florida, along a series of left and right lateral strike-slip faults. These strike-slip faults, including the precursor to the Jay Fault, formed in response to the differential stresses in Gondwana resulting from a deformational collision with Laurentia. The process is demonstrated in Figure 19, which illustrates the formation of strike-slip faulting in the Florida basement and the relative movement of terrane fragments in response to differential closure around the Alabama Promontory.

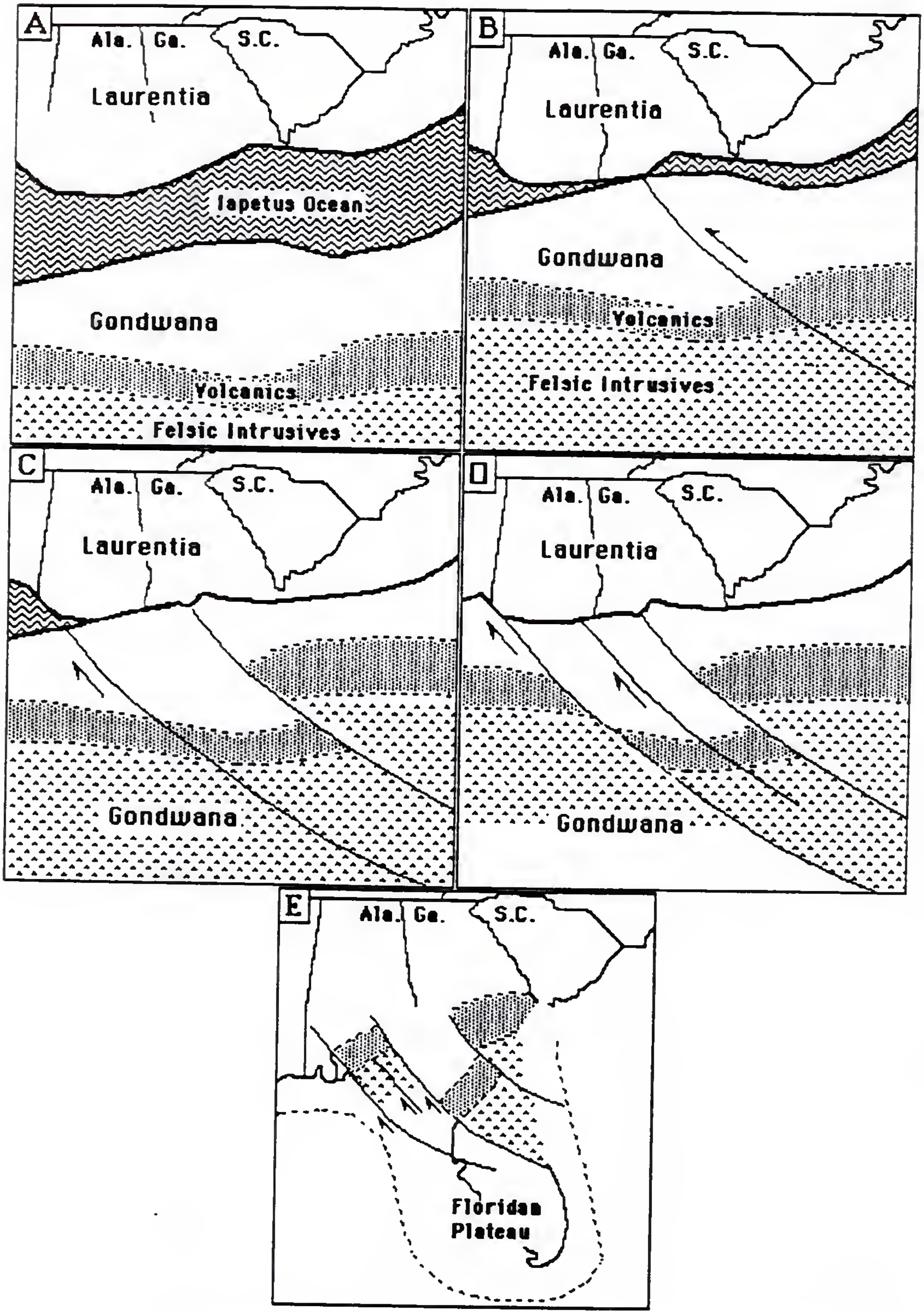


Figure 19. Hypothesized sequence of events during Alleghenian closure resulting in the translocation of Gondwanan terrane fragments along transform faults in the Floridan Plateau basement (after Smith, 1993).

There are other lines of evidence that support this scenerio. It is unlikely that the numerous Triassic and Jurassic features of the plateau basement would share a common linear boundary such as the Jay Fault zone (Chapter 2), unless this boundary existed as a pre-existing zone of weakness. The continuity and linearity of this zone of weakness is strongly suggestive of a long strike-slip fault zone, which is consistent with Smith's model. In addition, the metamorphic Catoche terrane encountered in DSDP holes 150 kms. west of the Florida Escarpment in the Gulf of Mexico is petrologically similar to the St. Lucie Metamorphic Complex and displays similar $^{40}Ar/^{39}Ar$ age spectra (Dallmeyer, 1984). Consequently, it appears to be another detached fragment of the same Gondwanan source terrane (Schlager et al., 1984). If one accepts a Gondwanan origin for the Catoche terrane, this necessitates northward to westward net transport relative to the present orientation of North America for emplacement of the terrane fragment to the west of the Florida Plateau. Because Mesozoic extensional trends suggest only southeastward transport, then northward to westward movement of the Catoche terrane must have occurred during or after closure, but prior to Mesozoic extension in some manner similar to that described by Smith.

Although significant northward and westward movement along a series of strike-slip faults is suggested, the amount of lateral offset along the Jay Fault zone may have been rather limited. Recent drill holes in the western Floridan Plateau have intersected granite (Ball et al., 1988; Dobson and Buffler, 1991). Although undated, this granite is located generally across the Jay Fault zone from the Osceola

Granite and is probably another fragment of the same terrane (Figure 17). In addition, Heatherington and Mueller (1991) have found little evidence for differences in Nd model ages for the lithospheric components from which the volcanic suite of the South Florida Basin and the north Florida volcanic rocks were derived. Each of these suggests that there was not enough net strike-slip movement along this section of the Jay Fault during the Paleozoic or Mesozoic to bring separate lithospheric units into juxtaposition.

Mesozoic

Most Late Paleozoic-Early Mesozoic reconstructions of Pangaea place the continental basements of the Floridan Plateau, the Yucatan, and the Bahamas Platform in the reentrant at the junctions between the juxtaposed North American, South American, and African plates. With the formation of a Late Triassic interior rift system, North America began to rift away from Gondwana along the traces of the Paleozoic continental margins (Van der Voo et al., 1976; Mullins and Lynts, 1977; Pindell and Dewey, 1982; Klitgord et al., 1983; Klitgord et al., 1984; Van Siclen, 1984). The hypothesized sequence of events on the Floridan Plateau during this period are shown in Figure 20.

A large graben system, the South Georgia Rift, formed across southern Georgia nearly along the trace of the Alleghenian suture between Florida and North America (Nelson et al., 1985B). The configuration of the rift was largely controlled by the presence of pre-existing lithotectonic structures, such as the suture, strike-slip faults, and various crustal blocks (Smith, 1993). The South Georgia Rift may have been contiguous with a continental rift that extended

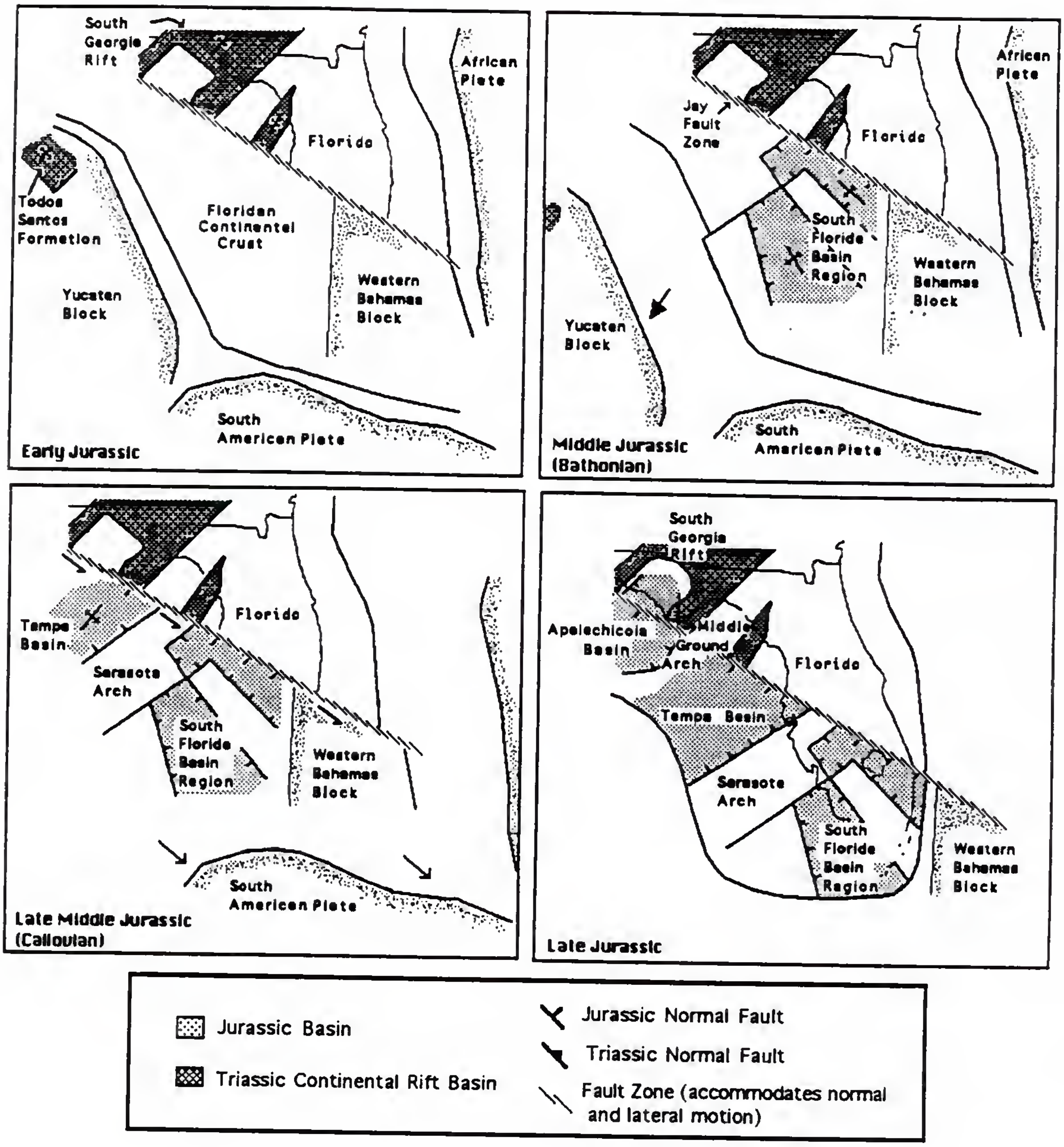


Figure 20. Hypothesized sequence of events during the formation of the Late Triassic and Jurassic extensional features of the Floridan Plateau basement.

across the Triassic northern margin of the Yucatan block, as suggested by the presence of red beds in the Todos Santos Formation of southern Mexico (Buffler and Sawyer, 1985; Molina-Garza et al., 1992). With a Late Triassic-Early Jurassic shift in the rifting geometry, the South Georgia Rift became an aulacogen and the Floridan Plateau, Yucatan, and western Bahamas basements were left appended to the southeastern margin of North America (Mullins and Lynts, 1977; Pindell and Dewey, 1982; Smith, 1982; Burke et al., 1984; Klitgord et al., 1984; Van Siclen, 1984).

Smith (1982) has suggested that this shift in the rifting geometry was caused by the formation of a Triassic hot spot and triple junction associated with the opening of the Atlantic Ocean near the southern tip of Florida. This model is supported by the ages, lithologies, and isotopic signatures of the bimodal rhyolitic and basaltic suite in the South Florida Basin region. The basalts of this terrane have yielded 40Ar/39Ar ages of about 190 Ma and trace elemental analyses have been found to be consistent with a mantle source, mixing with Precambrian continental lithosphere, and deposition in an extensional environment (Mueller and Porch, 1983; Heatherington and Mueller, 1991).

Both the configuration of the Floridan Plateau basement and recent continental reconstructions suggest that the South Florida Basin suite is more likely to be associated with the opening of the Gulf of Mexico, rather than the Atlantic Ocean. The alternating basins and arches of the southwestern Florida Plateau clearly indicate crustal attenuation in a southeasterly direction during the Middle Mesozoic. Restoration of that attenuation necessitates the relocation

of the South Florida Basin terrane to the northwest. In addition, as suggested by the position of the salient between Africa, North America, and South America, it is likely that during the Triassic and Jurassic, the continental crust of the western Bahamas block was located immediately to the east of the South Florida Basin terrane (e.g., Mullins and Lynts, 1977), where it would have effectively isolated the terrane from the Atlantic oceanic rift zone (Figure 20). Although these reconstructions suggest that the South Florida Basin was geographically removed from the Atlantic Ocean and that the bimodal volcanics were erupted as a consequence of the opening of the Gulf of Mexico basin, this does not negate a Late Triassic-Early Jurassic shift in oceanic rifting geometry as a causal mechanism for the failure of the South Georgia Rift.

A number of Late Triassic reconstructions of the Gulf of Mexico region indicate that the north-central Gulf region was occupied by the Yucatan (or Maya) Peninsula block which, as supported by recent paleomagnetic data (Molina-Garza et al., 1992), later rotated counterclockwise away from North America during its separation with South America (e.g., Pindell, 1985; Ross and Scotese, 1988; Rowley and Pindell, 1989). These reconstructions suffer from a gap in the northeastern Gulf of Mexico. There have been two general hypotheses that account for this gap.

One hypothesis is that the gap was occupied by the crustal blocks now occupying the Florida Straits and the South Florida Basin (Pindell, 1985; Ross and Scotese, 1988; Rowley and Pindell, 1989; Molina-Garza et al., 1992; Bartok, 1993). In this model the blocks were displaced about 150 km to the southeast with respect to north

Florida during the Late Jurassic. This displacement would have occurred along a left-lateral strike-slip fault (the Florida Elbow Fault) which would necessarily extend across the southwestern quarter of the Floridan Plateau (Figure 16B). The second hypothesis is that any apparent gaps are accountable entirely to attenuation and subsidence of continental crust in the eastern gulf during the Jurassic (e.g., Buffler and Sawyer, 1985; Dunbar and Sawyer, 1987; Salvador, 1987; Winker and Buffler, 1988).

In contrast to the obvious potential-field signature attributable to the Jay Fault zone, there is no suggestion of a Florida Elbow Fault extending across southwestern Florida in either Bouguer anomaly maps or seismic reflection surveys. In addition, the Middle Jurassic basins and arches of the southwestern Floridan Plateau appear to extend undisturbed across the proposed trace of the Florida Elbow Fault. Hence, there is little supporting evidence for this fault or any similar structure across the southwestern plateau, and the translocation of the Florida Straits block from the eastern gulf to its present location by some other path seems unlikely.

Another consideration with respect to the apparent gap is that the southwestern half of the Floridan Plateau is comprised of attenuated (i.e., stretched and thinned) continental crust, as suggested by the prominent extensional basins and the drill holes intersecting granitic basement (Figure 1). The depth-to-basement in the Tampa, Apalachicola, and South Florida Basins demonstrates that this block of continental crust has been moderately attenuated, with a beta value (i.e., the ratio of the stretched length to the original length as suggested by geometric reconstructions) of between 1.2

and 1.8 (Pindell, 1985). Consequently, the model that attributes an apparent gap in the northeastern Gulf of Mexico exclusively to the attenuation and subsidence of continental crust is preferred.

As previously mentioned, restoration of the Jurassic crustal attenuation of the southwest Floridan Plateau results in the relocation of the South Florida Basin region into the proximity of the eastern gulf. Potential-field maps indicate that the South Florida Basin region is comprised of several separate basins which trend northwest-southeast, perpendicular to the trend of the other Mesozoic features of the southern and western Floridan Plateau (Figure 18). The northwest-southeast orientations of these basins and their proximity to the Yucatan during the Late Triassic-Early Jurassic suggests that they may have formed in response to southwestern extensional stress as the Yucatan block rotated counterclockwise away from the Floridan Plateau (Figure 20).

Subsequently, as North America and South America continued to separate, a series of basement horsts and grabens formed around the periphery of the Gulf of Mexico basin (Pindell and Dewey, 1982; Burke et al., 1984; Klitgord et al., 1984; Buffler and Sawyer, 1985; Pindell, 1985; Winker and Buffler, 1988). A few of the horsts in the southeastern United States, such the Wiggins Arch underlying southern Alabama and Mississippi, have been proposed to be stranded blocks left behind by the departing Yucatan block or South American continent (Smith et al., 1981; Pindell and Dewey, 1982; Pindell, 1985; Van Siclen, 1990); however, most are considered to be the product of differential attenuation of original or transplanted

North American crust (e.g., Pindell, 1985; Ball et al., 1988; Winker and Buffler, 1988; Dobson and Buffler, 1990; Reitz, 1991).

The Gulf of Mexico existed as a restricted basin from about 165 Ma until about 150 Ma, resulting in the deposition of extensive salt deposits (Pindell and Dewey, 1982; Salvador, 1987). During this period, stress in the western Floridan Plateau was reoriented to a north-south or northwest-southeast extensional regime, as delineated by the northeast-southwest orientations of the horsts and salt-containing basins of the southwestern Floridan Plateau. This shift in the stress regime is likely to have been associated with the continuing separation of the North American and South American landmasses.

The mechanisms of relative motion between North and South America during the Jurassic are not well constrained, partly because much of the intervening crustal structure was subsequently destroyed during the eastward migration of the Caribbean plate. It is probable that the relative motion between the two continents was accommodated by strike-slip movement along a series of northwest-southeast or north-south oriented transform faults (Pindell and Dewey, 1982; Klitgord et al., 1984; Van Siclen, 1984; Pindell, 1985; Salvador, 1987).

It has been suggested that the Bahamas Fracture Zone/Jay Fault system acted as an important transform fault in the eastern Gulf of Mexico during the Jurassic, not only by accommodating significant sinistral displacement associated with the separation of North and South America, but also by forming the southern edge of continental North America (Pindell and Dewey, 1982; Klitgord et al.,

1984). However, as mentioned, the plateau basement southwest of the Jay Fault zone appears to be composed entirely of attenuated continental crust, rather than of stranded individual blocks, as had been hypothesized. In addition, similarities between Nd isotope signatures of basement samples from north and south Florida imply little net strike-slip motion along the Jay Fault zone (Heatherington and Mueller, 1991). Consequently, while some sinistral motion along the Jay Fault zone during the Jurassic resulting from crustal attenuation along its southwestern margin is likely, its proposed roles as the southern boundary of North American continental crust and as a major transform boundary seem implausible.

Tensional deformation in the Gulf of Mexico region ceased by the Late Jurassic (Salvador, 1987), indicating that the lithotectonic blocks of the Floridan Plateau had reached their present relative positions by that time. A review of existing seismic reflection profiles reveals no evidence of continued faulting or other tectonically-induced deformation in the sedimentary column overlying the Floridan Plateau after the Early Cretaceous, despite the presence of numerous pre-existing potential zones of weakness. Thus, as soon as the region became established as a passive margin, the level of crustal stress on the plateau appears to have diminished dramatically.

Cenozoic

In the time since the formation of the basins and arches of the southwestern Floridan Plateau basement, the entire plateau has been tectonically quiescent. A period of tectonism in the southeastern Gulf

of Mexico associated with the collision of Cuba and the Bahamas during the Early Paleogene has been documented; however, there is no evidence for any associated tectonic activity or significant horizontal lithospheric stress on the Floridan Plateau (Pindell, 1985). Rather, the undisturbed Upper Cretaceous and Tertiary strata on the plateau document an extended, nearly continuous period of shallow marine carbonate and clastic deposition which occurred in response to regional subsidence.

CHAPTER 4
SEISMICITY AND STRESS IN THE SOUTHEASTERN UNITED STATES

Introduction

Several hypotheses have been developed to explain seismic activity in the intraplate setting of the eastern United States; however, specific causal mechanisms and conditions remain enigmatic. The relative paucity of earthquakes and the tectonic complexity of the region result in seismic hazard assessments that are necessarily rather subjective and often the source of debate. An improved understanding of seismicity and seismic hazard in the eastern United States is necessary and can best be acquired from the integration of a variety of observations.

The intention in this chapter is to characterize epicentral density patterns in the southeastern United States and to provide a summary of the disparate hypotheses and observations relating to the seismicity of the region. A further objective is to evaluate possible causes for the nonuniform distribution of seismicity, with particular emphasis on the seismotectonic differences between the active South Carolina-north Georgia seismic zone and the juxtaposed, yet seismically quiescent south Georgia-Floridan Plateau region.

Methods

The characterization of epicentral distribution in the southeastern United States was accomplished through the integration of a literature review of historical and instrumental records and the establishment of a network of digital seismographs in Florida. This seismograph network has been in operation since 1989. In addition, a review of previously published seismic reflection profiles and an overview of the tectonic setting, as discussed in Chapters 2 and 3, respectively, are used as general indicators of prehistoric seismic activity for the Floridan Plateau.

Results

Epicentral Distribution in the Southeastern United States

Compilations of historic reports of seismic activity in the southeastern United States, except for Florida, have been provided by Bollinger (1973A, 1975). In these compilations, about 800 reported events during the period between 1754 and 1974 are identified. Of these, 76 reports are from eastern Tennessee, 73 are from North Carolina, and 451 are from South Carolina, while only 34 are from Georgia and 18 are from Alabama (Figure 21). Nearly all of the Georgia and Alabama events occurred in the northern portions of the states. The remainder of the reports are from Virginia, West Virginia, Maryland, and Kentucky. Based on this compilation, Bollinger identified several different seismically active zones in the southeastern United States.

The South Carolina-north Georgia seismic zone extends from the coasts of South Carolina and Georgia northwestward for about

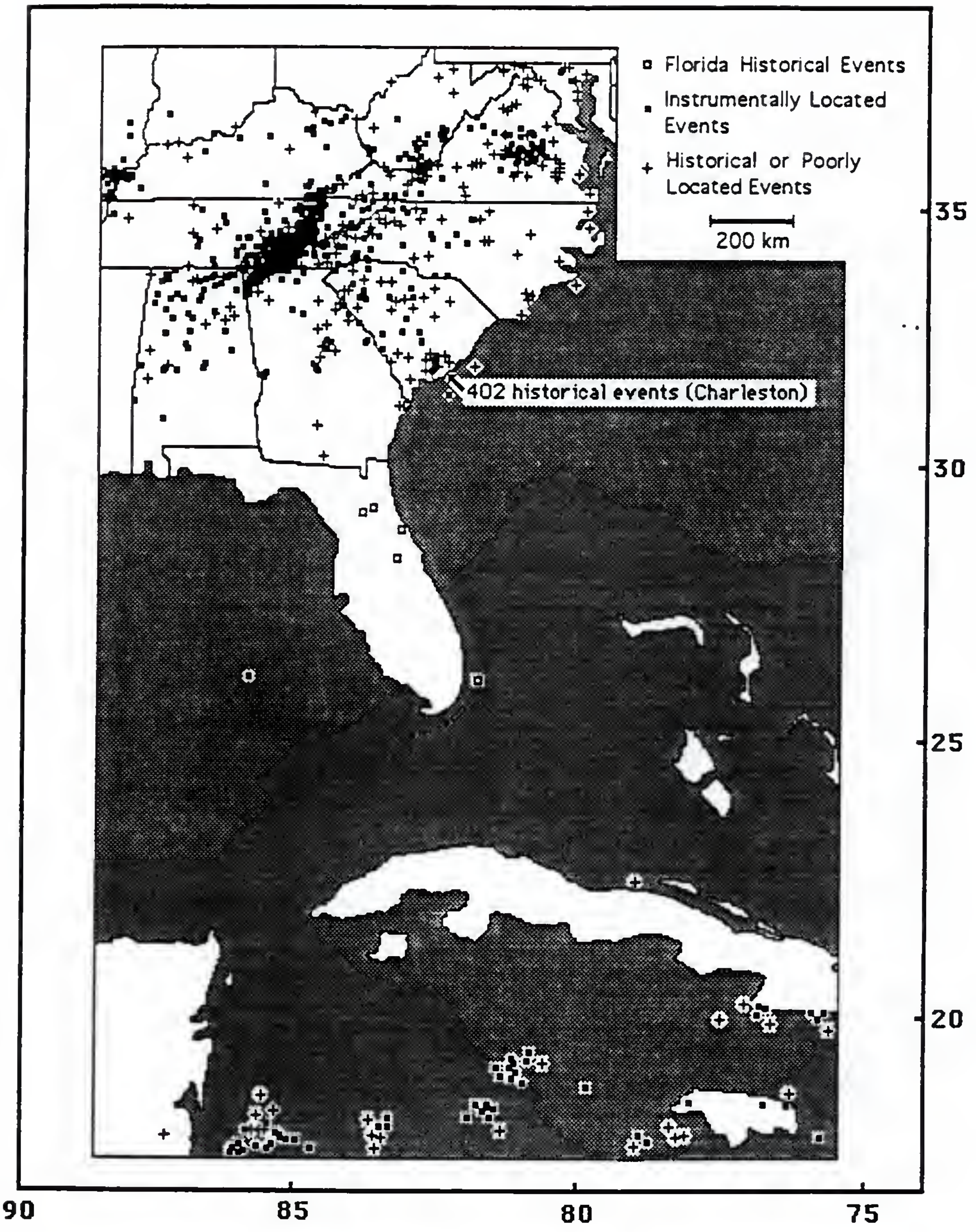


Figure 21. Epicentral distribution in the southeastern United States and northwestern Caribbean from historical and instrumental records. Compiled from Bollinger (1973A), Stauder (1982), Sykes et al. (1982), Mott (1983), Smith and Randazzo (1989) and SEUSSN Contributors (1992).

350 kilometers. It covers an area of more than 145,000 square kilometers and trends perpendicular to the structural grain of the Appalachians (Bollinger, 1973A,B). Although epicentral distribution within this zone is diffuse, it includes Charleston, S.C., where an 1886 event had an estimated body-wave magnitude of 6.8 (Bollinger, 1977, 1983) and a lengthy aftershock sequence, including more than 300 events during the subsequent 35 year period (Tarr, 1977).

Another zone, the Southern Appalachian seismic zone, extends from central Alabama northeastward to western Virgina along the Blue Ridge and Valley and Ridge provinces. It encompasses 162,000 square kilometers and, with respect to epicentral density, is more active than the South Carolina-Georgia seismic zone. Eight events with Modified Mercalli (MM) intensities greater than VI have occurred in this zone since 1874, including the intensity VIII event of Giles County, Virginia in 1897.

In addition to the historic reports of seismic activity, epicentral distribution patterns have also been determined from instrumentally located events. During the period from 1977-1991, the Southeastern United States Seismological Network (SEUSSN) located 1162 events, which are also shown in Figure 21 (SEUSSN Contributors, 1992). These instrumental records generally corroborate the previously determined epicentral distribution patterns of Bollinger, implying that the effects of population distribution, local ground response, and reporting error have not significantly biased the historical record.

In contrast, the south Georgia-Floridan Plateau region is characterized by an unusually low level of seismic activity. From a comprehensive review of historical records dating back to 1727, Mott

(1983) identified only 33 reports of earthquakes in Florida; these reports were later used to construct a seismicity map of the state (Reagor et al., 1987). Most of these reports do not represent tectonic activity in Florida (Smith and Randazzo, 1989; Lord and Smith, 1991). Rather, many are attributable to events that occurred elsewhere and others, based on their descriptions, are more likely to have been blasting, military activities, or atmospheric phenomena. The conclusion of these reviews was that Florida has experienced only 6 possible low-intensity historic events. A subsequent review of newspaper reports has revealed that 1 of these 6 possible events (on 21 June 1893) was felt in the Charleston area before being felt in Florida and, therefore, is not likely to have originated on the Floridan Plateau. The remaining 5 possible events are shown on Figure 21.

Instrumental records also support the premise that the Floridan Plateau, which includes south Georgia, is characterized by an unusually low level of seismic activity. In fifteen years of operation, the SEUSSN has never detected an event on the Floridan Plateau. In addition, during the three years that the state-wide network of digital seismographs has been in operation, there were no events located on the plateau and only a single local event was detected. This was a m_b 3.8 event located in the Gulf of Mexico, 340 kilometers west-southwest of Sarasota, Florida on March 31, 1992.

In addition to historical and instrumental records, a review of existing seismic reflection surveys from around the plateau (Chapter 2) shows no evidence of faulting, fault reactivation, or any other tectonically-induced movement since the Late Cretaceous. Thus, the

plateau basement appears to have been in a low-seismicity state for a relatively long period of time.

Consequently, historical records, instrumental records, and geophysical data each demonstrate a pronounced difference in levels of seismic activity between proximal regions. To the north, in the southern Appalachians and southern Coastal Plain, there is a moderate to high level of seismic activity, including several historic large magnitude events. Immediately to the south, however, there is an unusually low level of seismic activity, with only occasional low intensity events. As inferred from Figure 21, the boundary between these two regions extends approximately east-west across south-central Georgia and Alabama and is a well-defined example of the nonuniform nature of seismicity in the southeastern United States.

Several plausible explanations for this nonuniform distribution of seismicity can be presented, although they are not mutually exclusive. The first is that this difference is caused by variability in the lithospheric stress field, as suggested by Hatcher et al. (1987). Another possible reason is that there are mechanical differences (i.e., lithology or structure) between adjacent zones (Wheeler and Bollinger, 1984). This would imply that local seismogenic features exert primary control over the distribution of seismic activity in the southeastern United States. A final possibility is that there is a systematic variability in the propensities of pre-existing fault zones to slippage. This would be attributable to variations in either the frictional coefficients or hydrostatic pore pressures (or both) in the faults (e.g., Zoback, 1992).

Lithospheric Stress in the Southeastern United States

While the stress regime in central and eastern North America has been established to be primarily northeast-southwest compressive (Zoback and Zoback, 1980; Zoback, 1992), there have been a number of contradictory observations. This suggests the possibilities of local perturbations in the regional field and/or the influence of a local stress field. As a result, the source(s) of seismogenic stress in the southeast is still rather speculative.

Stress orientations in the Coastal Plain and southern Appalachian provinces have been determined from a variety of sources, such as the orientation of recent faulting (Schafer, 1979; Zoback and Zoback, 1980; Wentworth and Mergner-Keefer, 1981, 1983), hydrofracturing in deep wells (Zoback and Zoback, 1980), in situ measurements (Hooker and Johnson, 1969; Zoback et al., 1978), fault plane solutions (Tarr, 1977; Tarr and Rhea, 1983; Johnston et al., 1985; Zoback, 1992), borehole elongation (Plumb and Cox, 1987) and crustal modeling (Kuang et al., 1989; Richardson and Reding, 1991). Within these provinces, there is general agreement that the maximum stress is compressional and horizontal. While most indicators suggest that the maximum compressional stress direction is oriented northeast-southwest, many are also indicative of a northwest-southeast oriented field.

A number of indicators have been used to infer northeast-southwest compression. One of these is shallow focal plane solutions in the Charleston area (Tarr, 1977; Tarr and Rhea, 1983). Of the three composite solutions, two indicate northeast-southwest compression and one indicates northwest-southeast compression. In

addition, Plumb and Cox (1987) measured borehole elongations from eastern Tennessee to Canada, including a number from west of the Appalachians, and found nearly their entire study area to be under northeast-southwest compression. While Plumb and Cox had no measurements from the southeastern Coastal Plain, Hooker and Johnson (1969) measured in situ stresses in 5 boreholes in Georgia, Virgina, and North Carolina. Their measurements were inconclusive, as their orientations ranged from nearly north-south to nearly east-west. Focal mechanisms from the southern Appalachians demonstrate that at depths averaging between 9 and 15 kms, the basement under the Appalachian detachment is under northeast-southwest compression (Johnston et al., 1985). Using a variety of indicators, Zoback and Zoback (1989) found the eastern and central United States to be under a relatively uniform northeast-southwest compressional field. More recently, M.L. Zoback (1992) found that of the 32 central and eastern United States earthquakes used in her investigation, 25 indicated slip compatible with northeast-southwest compression.

Alternatively, some of the stress field indicators suggest a component of horizontal compressive stress oriented approximately northwest-southeast. Schafer (1979) came to this conclusion while investigating recent surficial fault motion in the western Valley and Ridge of eastern Tennessee, as did Wentworth and Mergner-Keefer (1981, 1983) and Prowell (1989) in studies of Cenozoic faulting from South Carolina to New England. Based on core hole offsets, hydrofracture tests, fault orientations, and focal plane solutions, Zoback et al. (1978) and Zoback and Zoback (1980) had initially

characterized the Appalachian and Coastal Plain provinces as being under northwest-southeast compression. Finally, Bollinger (1983) and Wentworth and Mergner-Keefer (1983) both concluded that the 1886 Charleston earthquake was probably a thrust event along a northeast-trending structure--another indication of northwest-southeast compression.

Within Florida, stress orientations have been deduced only from a single report of recent tectonic faulting (Vernon, 1951). In this account, Vernon proposes northwest-striking normal faulting in the west-central portion of the peninsula as a source of aerial photo lineations and inconsistencies in drill logs. The report has subsequently been cited as evidence for northeast-southwest extensional stress on the Floridan Plateau (York and Oliver, 1976; Zoback and Zoback, 1980; Prowell, 1983). No other reports of these features exist, and no physical recognition of them has been achieved, although northwest-trending jointing is common in that area (Beatty, 1977). Accordingly, the orientation of the stress field under the Floridan Plateau is unknown, although Zoback and Zoback (1989) indicate that southeastern Georgia and the Atlantic continental margin off Florida's northeast coast are under north-northeast to south-southwest compression.

In an attempt to explain the contradictory indicators of stress direction in the southern Appalachians and Coastal Plain, York and Oliver (1976) suggested that seismogenic stresses in the eastern United States vary both spatially and temporally. Wentworth and Mergner-Keefer (1983) suggested that the normal northwest-southeast compressional regime in the Charleston area had been

perturbed by the strain release during the 1886 event and has not yet recovered. Bollinger (1983) hypothesized that there were two sets of perpendicular seismogenic features around Charleston, one northwest-southeast and one northeast-southwest, along which earthquakes occur without regard to the orientation of the stress field. McCartan and Gettings (1991) proposed that young mid-crustal plutons locally disrupt the stress field by concentrating stress. Hatcher et al. (1987) suggested that the eastern and central United States could be divided into a number of individual blocks based on geophysical signatures and that a southern group of blocks, including the Floridan Plateau, are decoupled from the regional stress regime. Although each of these may explain certain observations or particular local phenomena, none resolves all of the contradictory observations throughout the eastern United States.

The total stress field at a given site is the sum of regional and local stresses. Regional stress, as the name suggests, is that stress regime which prevails over a large area and is produced by tectonic effects (e.g., Kuang et al., 1989). Local stress is that induced by surficial topographic relief or shallow crustal features or phenomena. Remnant stress is that stress remaining in a rock after an applied stress has been removed (Sbar and Sykes, 1973).

The primary source of regional stress in eastern North America appears to be ridge-push from the mid-Atlantic ridge (Yang and Aggarwal, 1979: Zoback and Zoback, 1980; Kuang et al., 1989; Zoback, 1992). This mechanism would be expected to produce a northeast-southwest oriented principal compressional stress direction. Other viable regional mechanisms of stress production include drag

resistance to plate motion (Zoback and Zoback, 1980) and lithospheric stress induced by asthenospheric convective flow (Voight, 1969; Sbar and Sykes, 1973). Either of these would also produce a northeast-southwest maximum compressional stress direction.

The contradictory indicators of stress direction suggest the possibility of a local stress stress field in the eastern United States. Several possible sources of local stress have been proposed. Bollinger (1973B) and Barosh (1981) have suggested isostatic uplift and flexure as a causal mechanism for compression; however, Brown (1978) was unable to find a correlation between vertical crustal movement and seismicity along the eastern seaboard. In addition, if the rebounding Appalachians are the source of the uplift in this model, then the predicted extensional stress along the crest of the mountains is not observed (Zoback and Zoback, 1980). Another proposed source of local northwest-southeast compressional stress is gravity-induced backsliding southeastward along the Appalachian decollement surface (Seeber and Armbruster, 1981). This model also predicts extension along the apex of the Appalachians, which is not observed (Zoback and Zoback, 1980). Finally, Kuang et al. (1989) considered the primary sources of local stress to be topographic relief and density contrasts within the lithosphere. According to their model, these would also be likely to induce northwest-southeast compression.

Seismotectonic Features of the Southeastern United States

While variability in the lithospheric stress field is one plausible mechanism to account for the nonuniform distribution of earthquakes, another is that there are mechanical differences

between adjacent zones (Wheeler and Bollinger, 1984). It is generally believed that seismic activity in the eastern United States occurs only along pre-existing faults or similar zones of weakness. Consequently, a comparison of the seismotectonic features of the southern Appalachians, the southern Coastal Plain, and the Floridan Plateau could reveal possible causes for this nonuniform distribution.

The multiphase accretionary history of the Appalachian orogen during the Paleozoic has been well-established (e.g., Williams and Hatcher, 1982; Secor et al., 1986). During these phases, the individual allochthonous terranes of the Appalachians were overthrust on and accreted to the North American craton during a long series of compressional events. The Alleghenian continental collision between Laurentia and Gondwana is particularly important to this investigation, as it marked the final stage of the Appalachian orogen and ultimately resulted in the accretion of the Floridan Plateau basement to North America (e.g., Wilson, 1966; Smith, 1982; Dallmeyer, 1987).

During Mesozoic rifting, there was a shift from a transpressional to an extensional regime in the southern Appalachians (e.g., Klitgord et al., 1983; Manspeizer and deBoer, 1989) which reactivated many pre-existing features (Swanson, 1986). Extensional basins are particularly prevalent under the Coastal Plain province; however, evidence of Mesozoic extension is found throughout the southeast (e.g., Swanson, 1986; Heck, 1989; Manspeizer and deBoer, 1989). Since the Cretaceous, the eastern United States has been a subsiding passive margin characterized by little tectonic activity, although there is evidence for widely scattered

compressional faulting (York and Oliver, 1976; Wentworth and Mergner-Keefer, 1983) and local isostatic uplift (Bollinger, 1973B; Brown, 1978).

The Grenvillian basement underlying this region is composed of a gneissic complex overlain by a lower Paleozoic metasedimentary sequence, which was probably deposited along the Iapetan Ocean continental margin (Cook et al., 1979; Nelson et al., 1987; Hubbard et al., 1991). Using reprocessed seismic reflection profiles supplemented by gravity and magnetic data, Hubbard et al. (1991) identified both thrust and normal faulting within the basal gneissic complex. These faults are believed to have formed during the Grenville compressional event (1100 Ma) and the Late Proterozoic-Early Cambrian extensional opening of the Iapetus Ocean, respectively. There are also reflection-free zones with corresponding potential-field anomalies that appear to be late or post-Grenvillian plutonic bodies. These intrusions appear to be undeformed, suggesting that the subsequent Paleozoic orogenies had little effect on the underlying basement. In addition, Hubbard et al. identified extensive thrust faulting in the metasedimentary sequence, as well as "bright spots" which are suggestive of hydrocarbon accumulation.

The southern boundary of this autochthonous crust corresponds to the Alleghenian suture zone between the Floridan Plateau and the Appalachian accreted terranes. The approximate trace of the suture has been constrained from deep bore hole data (Chowns and Williams, 1983) and interpretations of COCORP seismic reflection profiles (Nelson et al., 1985A) as striking approximately east-west across south-central Georgia (Figure 22), where the

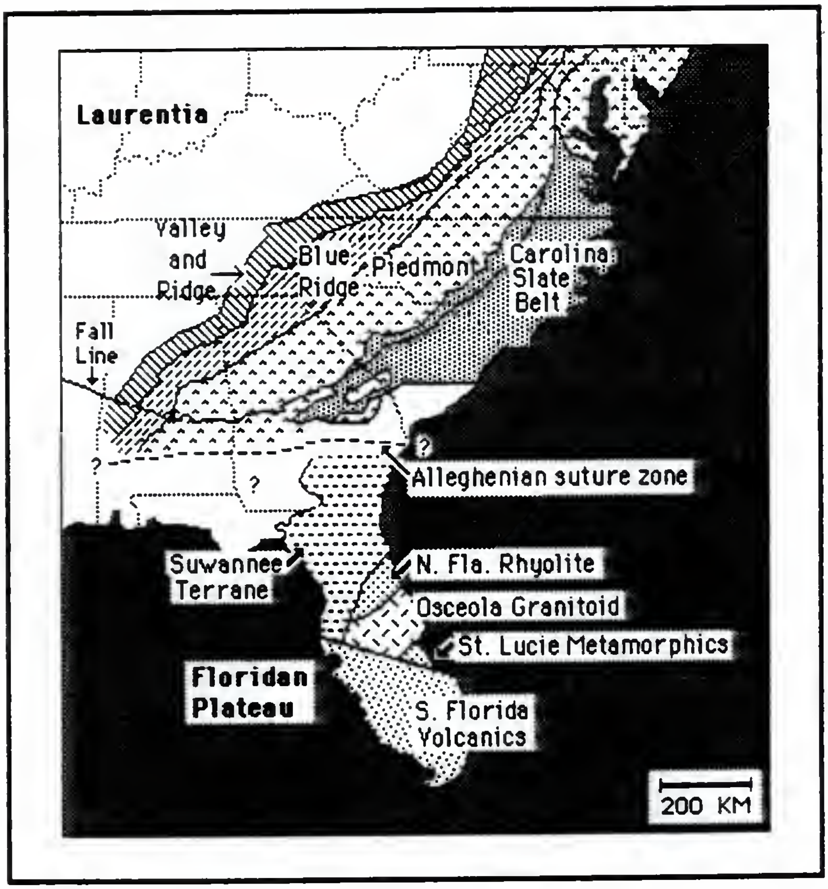


Figure 22. Pre-Mesozoic allochthonous terranes of the southeastern United States. Compiled from Seeber and Armbruster (1981), Smith (1982), Chowns and Williams (1983), and Thomas et al. (1989).

Triassic South Georgia Rift is superimposed over portions of it (e.g., McBride, 1991).

The allochthonous Paleozoic terranes of the southern Appalachian seismic zone are well-exposed and documented; they are characterized by northeastward-striking thrust faults that sole into a major southeastward-dipping decollement surface (Cook et al., 1979; Harris and Bayer, 1979; Williams and Hatcher, 1982; Secor et al., 1986; Heck, 1989; Horton et al., 1989). In contrast, the Paleozoic terranes and associated seismotectonic features of the South Carolina-north Georgia seismic zone and Floridan Plateau are buried under recent Coastal Plain sedimentary deposits and are not as well characterized. Similar northeast-trending thrust faults presumably extend under the Coastal Plain province as far south as the Alleghenian suture zone.

Mesozoic extensional features related to the openings of the central Atlantic and Gulf of Mexico are present throughout the southeastern United States (Figure 23). As shown in Chapter 2, the basement of the southern and western Floridan Plateau is characterized by a series of fault-bounded Jurassic extensional basins formed during the opening of the Gulf of Mexico (Pindell and Dewey, 1982; Klitgord et al., 1984; Ball et al., 1988; Winker and Buffler, 1988). Similarly, numerous fault-bounded Triassic rift basins are found along the eastern continental margin, such as the Blake Plateau Basin and Carolina Trough, and underlying the Coastal Plain, such as the South Georgia Rift and the Florence Basin. In addition, analogous Triassic rifts, such the Dan River and Culpepper Basins, are also found in the east-central Appalachians (Klitgord and Behrendt, 1979;

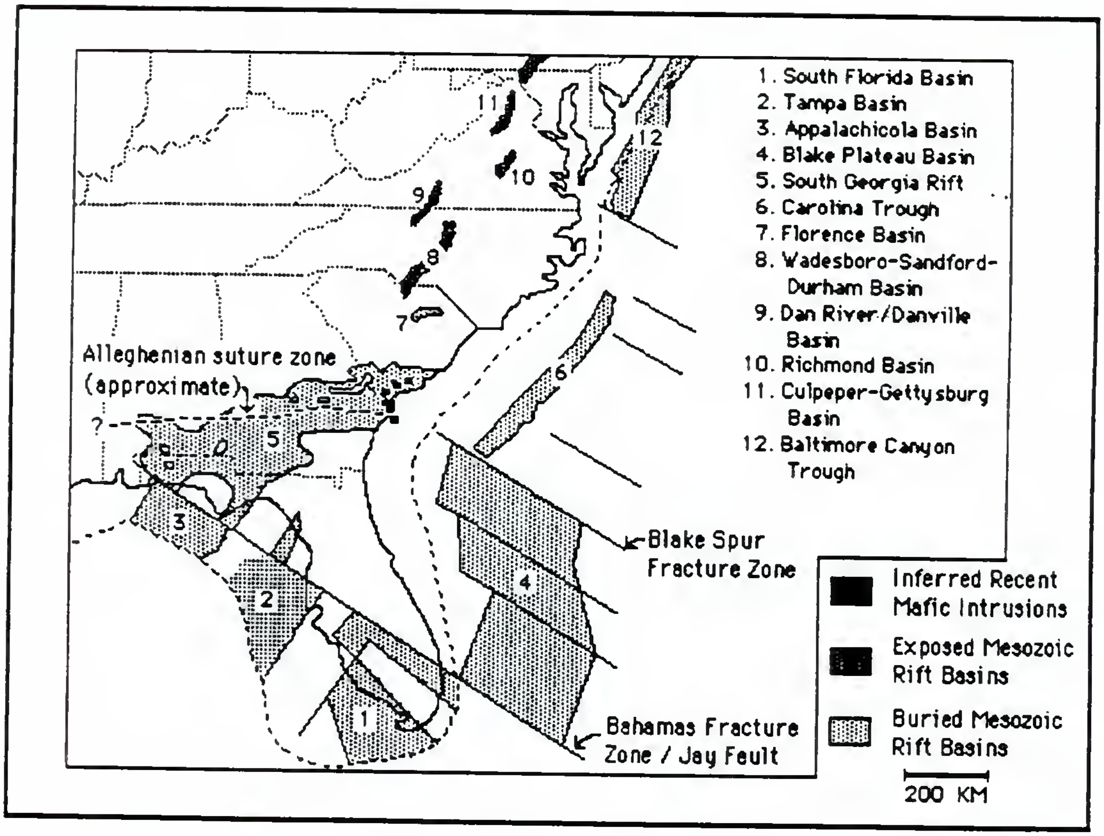


Figure 23. Selected Mesozoic seismotectonic features of the southeastern United States. Some features compiled from Klitgord and Behrendt (1979), Chowns and Williams (1983), Daniels et al. (1983), and Heck (1989).

Daniels et al., 1983; Swanson, 1986; Heck, 1989; Manspeizer and deBoer, 1989). While there is no evidence for normal faulting as far west as the southern Appalachian seismic zone, the basements of the South Carolina-Georgia seismic zone and the Floridan Plateau have each been extensively faulted.

Other than the isostatic uplift of the Appalachians and the subsidence along the Coastal Plain and continental margin, there is little evidence of significant tectonic activity during the Cenozoic, although Schafer (1979), Wentworth and Mergner-Keefer (1981, 1983), and Prowell (1989) have described a few small reverse faults scattered throughout the Appalachians and the Coastal Plain. In addition, based on heat flow and potential-field maps, several investigators have suggested the presence of potentially seismogenic Cenozoic, mid-crustal mafic intrusions in the Coastal Plain of South Carolina (Kane, 1977; Long, 1977; McKeown, 1978; McCartan and Gettings, 1991). Other than these examples, there are no known post-Jurassic potentially seismogenic features in the southeastern United States.

Pore Pressure and Frictional Coefficients

Another possible reason for the nonuniform distribution of seismicity in the eastern United States is a regional variation in the potential for movement along pre-existing faults. The potential for slippage along a fault in a given stress field is a function of two dependent variables--the coefficient of friction and the hydrostatic pore pressure. Greater pore pressures and lower coefficients of friction each increase the probability of slippage. Although there are

no direct measurements of these variables in the east, some characterizations are possible.

In a study of eastern United States earthquakes, Zoback (1992) assumed an average hydrostatic pore pressure for each fault and calculated the coefficient of friction required for slippage in the given stress regime. The variables were then reversed and required pore pressures were calculated using an assumed coefficient of friction. She found the range of calculated pore pressures and frictional coefficients for the majority of events to be well within expected values. Based on these results, it appears that moderate lateral variation in either hydrostatic pore pressure or coefficients of friction (or both) is a plausible mechanism for the nonuniform distribution of seismic activity in the eastern United States.

Discussion

Based on recent studies of lithospheric stress, seismicity, and the distribution of autochthonous and allochthonous crustal blocks in the southeastern United States, it is possible to evaluate some of the variables that could result in the observed nonuniform distribution of seismic activity. Most of the seismic activity is probably attributable to a regional northeast-southwest compressional stress field (Zoback, 1992). This regional field appears to be relatively uniform with respect to magnitude and orientation, suggesting no causal relationship to the nonuniform distribution of earthquakes. Some focal mechanisms and other shallow crustal indicators of lithospheric stress are suggestive of northwest-southeast compression, implying the influence of a shallow local stress field as

one possible causal mechanism for the nonuniform earthquake distribution. Hypothesized mechanisms for the generation of a northwest-southeast compressional field focus on density contrasts or topographic influences in the shallow allochthonous terranes overlying the Appalachian detachment (e.g., Kuang et al., 1989) or on gravity-induced stress and slippage along the detachment surface (e.g., Seeber and Armbruster, 1981).

Recent hypocenter determinations suggest that most of the seismic activity in the southeast occurs below the Appalachian detachment in the autochthonous Grenvillian basement and is caused by the regional stress field (e.g., Bollinger et al., 1985; Johnston et al., 1985; Zoback, 1992). Consequently, while the influence of a shallow local topographically-induced stress field might account for some of the observed earthquake distribution, it is probable that this effect is subordinate to the influence of the regional field.

There has been considerable discussion concerning possible relationships between the various provinces and terranes of the Appalachians and the distribution of seismic activity. For example, Wheeler and Bollinger (1984), while acknowledging the possible role of faults in the autochthonous basement, also tentatively attributed the nonuniform distribution of earthquakes in the southeastern United States to differences between these various allochthonous terranes. Similarly, Drumheller et al. (1981) divided the eastern U.S into 5 seismotectonic regions, which were then correlated to several Appalachian provinces. The subsequent recognition that most of the seismic activity in the eastern United States occurs below the Appalachian decollement, however, affirms that the distribution of

earthquakes is largely unrelated to the near-surface, Paleozoic accreted terranes or seismotectonic features.

Similarly, the distribution of Mesozoic rift basins is unlikely to be a causal mechanism for the nonuniform distribution of earthquakes. Not only are these shallow crustal features, but Mesozoic extensional faulting is pervasive throughout the southeast and is particularly prevalent under the relatively aseismic Floridan Plateau. Thus, there is no apparent correlation between the distribution of Mesozoic extensional faults and the distribution of earthquakes in either a lateral or horizontal sense.

One hypothesis relating recent seismicity to Mesozoic tectonic effects is that large events in the eastern United States occur preferentially along zones of lithospheric weakness near the onshore ends of Jurassic oceanic transform zones (Sbar and Sykes, 1973; Sykes, 1978). For example, the hypothesized onshore extension of the Blake Spur Fracture Zone passes through centers of the South Carolina-north Georgia and southern Appalachian seismic zones (Figure 23). Although this fracture zone may extend downward into the seismically active autochthonous basement, it is probably a near-vertical feature that strikes perpendicularly to the prevailing regional stress field and would therefore be unlikely to experience movement.

In addition, other parallel fracture zone traces show no particular seismogenic tendencies. For example, the Bahamas Fracture Zone probably extends across the Floridan Plateau as the Jay Fault and connects with the Gulf Basin marginal fault zone (Smith, 1982; Chowns and Williams, 1983; Klitgord et al., 1984; Smith et al.,

1992). However, none of the previously mentioned historic events in Florida occurred near the Jay Fault. In addition, seismic reflection profiles along the eastern edge of the plateau show no evidence of displacement in the Cretaceous to Recent sedimentary layers overlying the fault zone, implying that there has been negligible Cenozoic movement (e.g., Sheridan et al., 1981). Consequently, it appears that Jurassic fracture zone traces in the eastern United States are not seismically unstable in the present stress field, and other mechanisms or features probably account for the observed seismic activity along these fracture zone traces.

While variations in the lithospheric stress field and the distributions of shallow crustal features and terranes do not account for the observed hypocentral distribution and focal mechanisms, the distribution of Iapetan faults or other pre-existing seismogenic features in the autochthonous Grenvillian crust may account for these observations. There is a growing body of evidence indicating that most, but not all, of the earthquakes in the eastern United States occur below the Appalachian detachment (e.g., Zoback, 1992). For example, while the top of the Grenvillian crust in the southern Appalachians is about 3 km deep (Hubbard et al., 1991), mean focal depths in the same area average about 12 km (Bollinger et al., 1985; Johnston et al., 1985).

In addition, there appears to be a strong spatial correlation between the observed epicentral distribution and Grenvillian continental margin. This correlation is particularly pronounced along the distinct boundary between the seismically active South Carolina-north Georgia seismic zone and the seismically quiescent Floridan

Plateau. This boundary correlates very well to the previously established trace of the Alleghenian suture zone which, as the boundary between the thin-skinned Appalachian orogen and the thick-skinned Floridan Plateau, also marks the southern boundary of the autochthonous Grenvillian crust (e.g., Harris and Bayer, 1979; Cook et al., 1981; Ando et al., 1983; Heck, 1989).

Consequently, the spatial relationship between the Late Proterozoic edge of the North American continent with contemporary hypocentral distribution promotes the hypothesis that seismic activity in the eastern United States occurs preferentially along faults associated with the opening of the Iapetus Ocean. The nonuniform distribution of seismic activity, then, would be a function of the distribution of optimally stressed Iapetan faults. The concentration of these faults along the Grenvillian eastern continental margin could account for a general decrease in observed seismic activity west of the Appalachians.

Other characteristics of the crust may also contribute to the nonuniform distribution of earthquakes. In seismic reflection profiles, Hubbard et al. (1991) found evidence of plutonic bodies in the Grenvillian crust, which suggests the possibility that some of the seismic activity could be due to the presence and distribution of these bodies. Similarly, Cenozoic mid-crustal plutonic bodies may account for some of the seismic activity in the Charleston area (McCartan and Gettings, 1991). Another possibility, as previously mentioned, is that there could be a lateral variability in the propensity for fault slippage due to changes in hydrostatic pore pressure or frictional coefficients.

Summary

The nonuniform distribution of seismicity in the southeastern United States may be the result of several different effects. Based on the uniform nature of the regional stress field and the spatial association of most eastern earthquakes with the edge of the autochthonous Grenvillian crust, it appears likely that seismicity in the southeast is largely attributable to the reactivation of optimally stressed Iapetan faults below the Appalachian detachment surface. Consequently, the nonuniform earthquake distribution primarily results from the nonuniform distribution or orientation of these faults.

While this mechanism accounts for much of the observed earthquake activity, it is certain that some earthquakes are attributable to other causal mechanisms. There has been some earthquake activity recorded in the overlying allochthonous Appalachian terranes, suggesting that the seismogenic effects of the regional stress field are not entirely limited to the Grenvillian crust. In addition, some of the shallow crustal focal mechanisms and other indicators of stress direction suggest the influence of a local compressional stress field that is perpendicular to the regional field. This local field or the interaction of the local and regional fields appears to cause intermittent reactivation of some shallow faults and may partially account for the observed spatial association between epicentral distribution and topography in the southern Appalachians. Other ancillary causal mechanisms for the observed distribution of seismic activity may include the distribution of seismogenic mid-

crustal intrusive bodies and variability in the propensities of fault zones for slippage.

However, contrary to some previous hypotheses, there appears to be no significant spatial relationship between the distribution of earthquakes in the southeast and individual Paleozoic allochthonous terranes or thrust features. Similarly, there appears to be no correlation between the locations of Mesozoic extensional basins or fracture zones and the distribution of earthquakes.

CHAPTER 5
REGIONAL SEISMOTECTONIC PROVINCES

Introduction

Probabilistic seismic hazard analyses in sites characterized by historically low levels of seismic activity, such as on the Floridan Plateau, must address the potential for ground motion resulting from seismic activity in surrounding areas. This is accomplished by dividing the region into a series of seismotectonic provinces and quantifying the level of seismic activity within each province. In addition, it is necessary to establish a regional value for crustal attenuation which describes the ability of the lithosphere to transmit seismic energy. Together, these allow an appraisal of the potential for ground motion at a site resulting from distant earthquakes and are integral elements in an assessment of seismic hazard.

A seismotectonic province is defined as a geographic region of some geological, geophysical, or seismological similarity that is assumed to possess a uniform earthquake potential throughout (Reiter, 1990). The intention in this chapter is to identify and provide a characterization of those seismotectonic provinces that could potentially experience earthquakes large enough to produce significant ground motion in Florida.

Background and Methods

A variety of approaches have been used to characterize the seismotectonic provinces of the southeastern United States. While many have used seismological similarities as the sole means of delineating the various provinces (i.e., Bollinger, 1973A; Drumheller et al., 1981), others have attempted to relate patterns of observed seismicity with known geological provinces or geophysical features (i.e., Wheeler and Bollinger, 1984; Hatcher et al., 1987). As inferred by Wheeler and Bollinger (1984) and discussed in Chapter 4, however, there is not yet enough information available to positively correlate seismicity with geologic provinces or features in the southeastern United States.

Another approach has been to use both seismological similarities and the presence of potentially seismogenic features in the shallow crust as a means of distinguishing these provinces (i.e., Khoury and Chandra, 1989). A problem with this approach is that potential seismogenic features are ubiquitous in the southeastern United States, yet few appear to have Cenozoic seismic activity associated with them (e.g., Chapter 4).

For example, three of the models presented by Khoury and Chandra include the Florida extension of the South Georgia Rift as a potential seismic source zone, yet there have been no historical or instrumental events in this area and seismic reflection profiles of the undisturbed overburden suggest no seismic activity since the Early Cretaceous (e.g., Arden, 1974; Nelson et al., 1985A; Dobson and Buffler, 1991). Furthermore, there has been no demonstrated association between similar structures and recent seismic activity

anywhere in the southeast. Hence, the assignment to southwestern Georgia and northwestern Florida of an elevated level of seismic hazard as compared to the numerous other southeastern locations underlain by Mesozoic extensional features seems unfounded.

Consequently, the utilization of geophysical signatures and geological information is not yet a practical method for the identification of seismotectonic provinces in the southeastern United States. Unfortunately, as discussed by Yegian (1979), historical and instrumental records encompass only a few hundred years and, therefore, may not provide a representative distribution of seismic activity. Nevertheless, the most tenable approach remains to utilize these seismic records in a judicious manner. The compilation of the seismic records for the southeastern United States and Caribbean (e.g., Figure 21) will be used as a foundation for the delineation of these provinces and the subsequent assessment of seismic hazard in Florida.

The identification of seismotectonic provinces in the Caribbean region allows the use of a slightly different approach. This difference results from the neotectonic setting of the Caribbean plate boundary and the association of seismic activity with known geologic structures along this boundary. In these instances, seismotectonic provinces may be delineated on the basis of both seismological similarities and geologic setting.

Following the identification of the seismotectonic provinces proximal to Florida, a characterization of the level of seismic activity within each of the provinces is necessary. This is accomplished through the assignment of an appropriate magnitude range and

recurrence interval to each province. While the determination of a maximum credible earthquake for a province in an intraplate region is largely subjective, a comprehensive review of historic intraplate earthquakes provides some control (Johnston and Kanter, 1990). For example, only 3 earthquakes of magnitude eight or above and only 15 earthquakes of magnitude seven or greater have occurred in any intraplate region during historic times. Johnston and Kanter indicate that these large magnitude intraplate events appear to be spatially associated with continental rifts and passive continental margins.

Generally, the maximum credible magnitude is assigned to a province at some increment above the maximum historic magnitude (Reiter, 1990). In provinces that have poorly documented historic records, including the eastern United States, the assignment of a maximum credible magnitude also takes into consideration the geologic setting, the level of recent seismic activity, and a reasonable allowance for error.

The assignment of a minimum magnitude to a seismic source significantly affects the calculated seismic hazard probabilities for lower levels of ground motion. There is no standard method of determining minimum magnitude. As pointed out by Bender and Campbell (1989), several magnitudes, ranging from m_b (body wave magnitude) 3.75 to m_b 5.0, have been adopted by various regulatory agencies and workers for use in the province surrounding the site of interest. Generally, the minimum magnitude assigned is based on an estimation of the magnitude of the smallest event occurring in that province that could be expected to cause damage at the site. Events

smaller than this are usually considered to be insignificant with respect to site specific seismic hazard analyses.

In long-term risk assessments, earthquake recurrence is commonly assumed to have a Poisson distribution, indicating that each event is independent of any other event. The recurrence interval, or the number of earthquakes (N_m) per unit time (usually one year) for a given magnitude (m), may be approximated by:

$$\log N_m = a - b(m) \qquad \text{(Gutenberg and Richter, 1944)}$$

where "a" is a constant which describes the rate of earthquake activity and "b", the slope of the regression line, indicates the relative numbers of small and large earthquakes. Hazard assessments generally employ this equation and the known frequency of smaller earthquakes in a given province to calculate the recurrence intervals of large destructive earthquakes. Thus, the value of "b" assumes a significant role as an indicator of seismic hazard. A typical "b" value in the eastern United States is about 0.8 (e.g., Bollinger et al., 1989).

The limited historic record necessitates the integration of historical and instrumental data in seismic hazard investigations, particularly for the calculation of recurrence intervals. It is often necessary to estimate magnitudes from historic intensity data. Although Sibol et al. (1987) derived a magnitude-intensity relationship specifically for the eastern United States, this relationship incorporates felt area, which is often not available. The estimation of magnitude (m_b) from intensity (I) is instead based on a

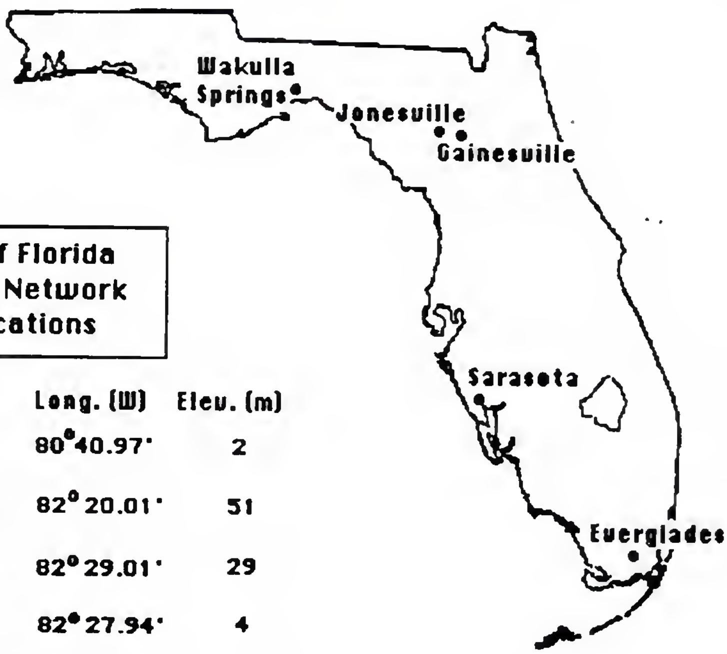
relationship derived by Veneziano and Van Dyck (1984) for the central and eastern U.S. as defined by:

$$m_b = 0.892 + 0.586(I)$$

The final step, then, in the characterization of the seismotectonic provinces is to calculate or assign "a" and "b" values to each province based on earthquake compilations of historic and instrumental data.

As it is not possible to calculate precise values from only a few historic events, as in Florida, the previously mentioned state-wide network of seismographs was established in 1989 in order to characterize the regional level of micro-earthquake activity (Figure 24). This network initially consisted of three stations, each equipped with three Teledyne S-13 short period seismometers coupled to a Teledyne PDAS-100 digital recorder. The stations were located at the University of Florida in Gainesville, in Oscar Scherer State Recreation Area near Sarasota, and in Everglades National Park at the southern tip of the state. The base station at Gainesville was also equipped with three Teledyne BB-13 broadband seismometers and a Sprengnether SS-80 short period analog seismograph. Subsequently, the digital base station was moved to Jonesville, which is just west of Gainesville, and an additional three-component digital station was established in Wakulla Springs State Park, just south of Tallahassee.

The digital seismographs are event-triggered, rather than being continuously recorded. The triggering algorithm continuously monitors the ratio of the amplitude of ground motion over a short period of time, typically one second, to the amplitude of ground



University of Florida
Seismograph Network
Station Locations

	Lat. (N)	Long. (W)	Elev. (m)
Everglades	25°23.24'	80°40.97'	2
Gainesville	29°39.02'	82°20.01'	51
Jonesville	29°41.00'	82°29.01'	29
Sarasota	27°10.53'	82°27.94'	4
Wakulla Springs	30°14.83'	84°17.90'	5

Figure 24. The University of Florida Seismograph Network.

motion over a long period of time (i.e., background noise). If that ratio exceeds a level set by the operator within a specified frequency, the digital recorder is then triggered and records for a set period of time, usually one to two minutes.

This algorithm is characterized by a decrease in the sensitivity of the seismograph with an increase in the background noise. Because most background noise is related to weather conditions and human activities, it is quite variable. Consequently, it is not possible to quantify the sensitivities of the seismograph systems. Based on the amplitude of the signal recorded at Gainesville during a m_b 3.8 event in the Gulf of Mexico in 1992, it is estimated that any event on the Floridan Plateau with a magnitude greater than 1.5 to 2 would be detected by the entire network.

Results

In addition to the general background seismicity of the Floridan Plateau, the Gulf of Mexico, and the Bahamas regions, there are several distinct seismotectonic provinces in southeastern United States in which earthquake activity could potentially cause perceptible ground motion in Florida. These include the Charleston province, which is enclosed by the Piedmont-Coastal Plain province, the Southern Appalachians province, and the New Madrid province. In addition, the Cayman Trough region, which is along the northern Caribbean plate boundary, may pose a potential seismic threat to Florida. The boundaries of these seismotectonic provinces are shown in Figure 25.

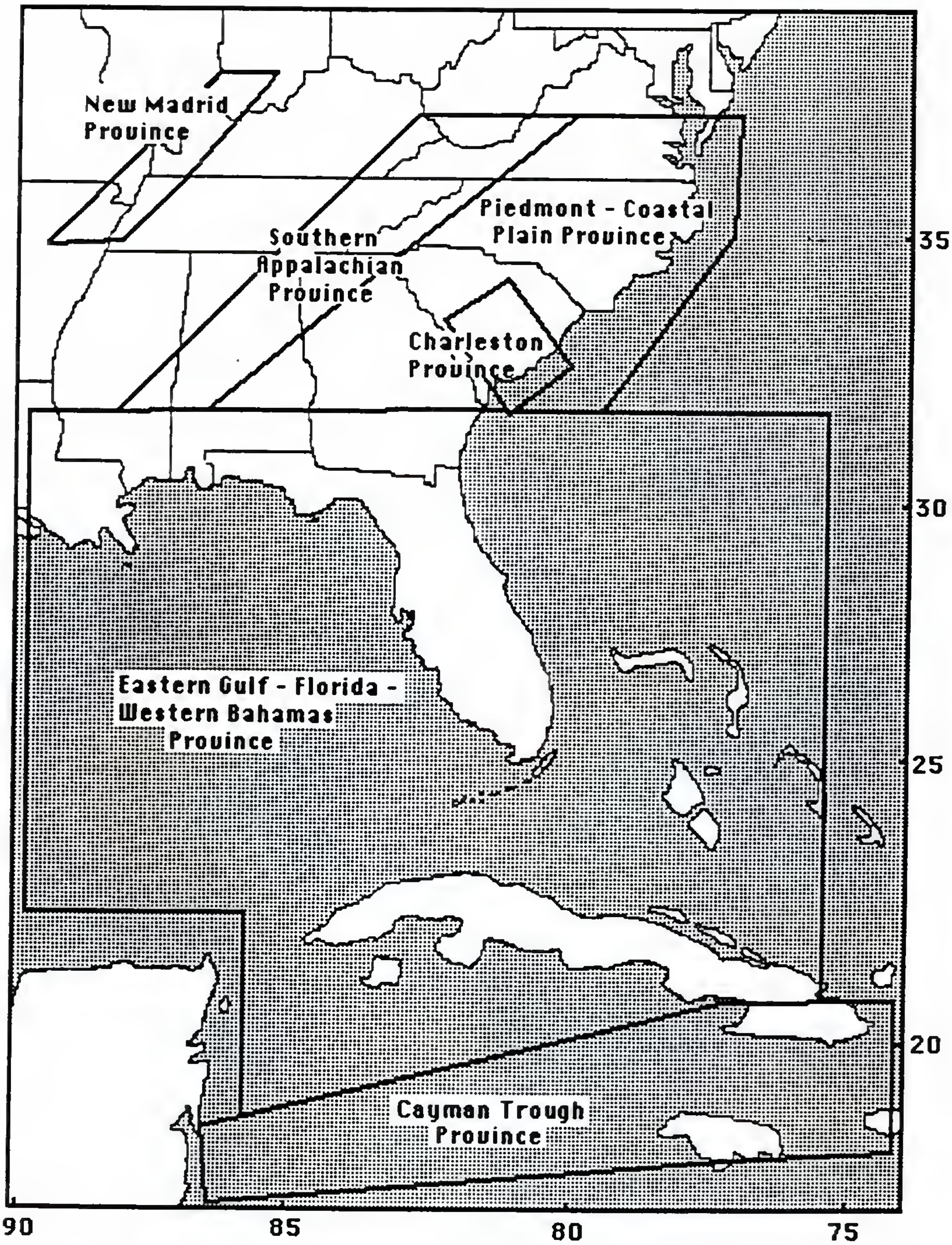


Figure 25. Seismotectonic provinces in which expected earthquakes could potentially cause significant ground motion in Florida.

The Floridan Plateau/Eastern Gulf/Western Bahamas Region

As discussed in Chapter 4, the level of historic seismic activity on the Floridan Plateau, in the eastern half of the Gulf of Mexico, and in the western Bahamas region is very low. Most of the events are clustered along the eastern edge of the Floridan Plateau. Although this clustering has possibly been biased by the population distribution, it is consistent with the previously observed spatial association between some passive continental margins and seismic activity (Johnston and Kanter, 1990). In deference to the need to be conservative, the level of seismicity suggested by this local cluster of events will be used as a regional gauge of seismic activity.

There have been only four instrumentally recorded events from this region. Two of the five Florida events were recorded at distant stations and subsequently assigned magnitudes. One was a m_b 4.0 event south of Orlando, Florida, which was recorded in Atlanta on Oct. 27, 1973 (Long, 1974). The other, on Nov. 4, 1975 near Daytona Beach, was recorded in Virginia and assigned a magnitude of m_{bLg} 2.9 (Minsch et al., 1975). In addition, there have been two instrumentally recorded earthquakes in the eastern half of the Gulf of Mexico. These include the previously mentioned m_b 3.8 event in the eastern Gulf of Mexico on March 31, 1992 and a m_b 3.6 event located about 250 km southeast of New Orleans on Sept. 27, 1992. Each of these was recorded by the University of Florida Seismological Network and others.

Housner (1969) assigned upper bound magnitudes to regions based on their tectonic settings. Intraplate regions characterized by low seismicity, such as Florida, were assigned maximum credible

magnitudes of either 4.25 or 4.75. The largest historic event occurred in northeast Florida or southeastern Georgia on Jan. 13, 1879 and was subsequently estimated to have been an intensity VI event (Mott, 1983). Using Veneziano and Van Dyck's relationship, this is approximately equivalent to a magnitude 4.4 earthquake. Considering the infrequency of earthquake activity, the low intensity of the largest historic event, the lack of geologic evidence for earthquakes, and Housner's criteria, it appears unlikely that this region will experience an event greater than m_b 5.0.

As previously mentioned, minimum magnitudes for the areas immediately surrounding targeted sites have ranged from m_b 3.75 to m_b 5.0. Intensities of less than MMI VI are, by definition, characterized by no structural damage to buildings. An intensity V event is approximately equivalent to a magnitude 3.8 earthquake; therefore, this will be the designated minimum magnitude for this province.

There is an insufficient number of events for the calculation of "a" and "b" values for this province. The "a" value, as a function of the rate of earthquake activity, is undoubtedly relatively low. Typically, "a" values in regions of low seismicity range from 0.8 to 1.3, while an expected "b" value would be in the 0.5 to 0.75 range. An estimated "a" value of 0.9 and a "b" value of 0.55 yields a recurrence interval of 70 years for the maximum credible magnitude event (m_b 5.0) and 20 years for a m_b 4.0 event. Comparison with the incidence of historic and instrumental events suggests these values to be reasonable approximations for the purpose of probabilistic hazard assessment.

Charleston Seismotectonic Province

Liquefaction features, such as sand blows, are only formed during earthquakes of approximately magnitude 5.8 or greater (Amick and Gelinas, 1991). In a study of the distribution of paleoliquefaction features along the entire southeastern Coastal Plain, Amick and Gelinas (1991) found that these features occur almost exclusively in the South Carolina Coastal Plain proximal to the city of Charleston. The one exception was a site located in North Carolina, near the South Carolina border and relatively close to the other paleoliquefaction features. Based on this study, it appears that the Charleston region is characterized by a higher maximum credible magnitude than the remainder of the southeast and that this region of elevated activity extends northeastward beyond the area originally described by Bollinger (1973A).

The geologic evidence for a locally elevated maximum credible magnitude is consistent with the historic record, as demonstrated by the m_b 6.7 (estimated) Charleston event of 1886 (e.g., Bollinger, 1977; Bollinger et al., 1989). Housner's (1969) designated upper bound magnitude for similar tectonic settings is 7.0, while other estimates of a maximum credible magnitude for the Charleston area range up to 7.4 (Ebasco, 1988). Although a 7.4 magnitude event is unlikely to occur in this zone, the assignation of this value as an upper bound magnitude is compatible with the desired goal of providing a conservative estimate of seismic hazard in Florida.

A minimum bound earthquake for this zone can be based on the estimated magnitude of the 1886 Charleston event and its effects in Florida. The estimated m_b 6.7 earthquake produced effects of MM

intensity V (i.e., no damage) in the northern half of the state (Bollinger, 1977). This suggests that for the purpose of this study, a designated minimum magnitude for this province should be no smaller than 6.5.

Recurrence interval estimates for large events in the Charleston zone based on paleoseismic evidence, such as the liquefaction features, range from 500 to 2400 years (Talwani and Cox, 1985; Obermeier et al., 1987; Amick and Gelinas, 1991). This range probably represents the expected variability in the recurrence interval with time, which suggests the 500 year estimate to be an approximate minimum interval between events greater than m_b 5.8. This corresponds very well to the calculation by Bollinger et al. (1989) of an "a" value of 1.65 and a "b" value of 0.77 for the Charleston zone, suggesting average recurrence intervals of 650 years for m_b 5.8 events and 11,200 years for m_b 7.4 events.

Piedmont-Coastal Plain Seismotectonic Province

The Piedmont and Coastal Plain of the southeastern United States are characterized by a moderate level of seismic activity which steadily decreases to the east, except in South Carolina and central Virginia. In a study of magnitude recurrence in the southeast, Bollinger et al. (1989) distinguished between the Piedmont and the Coastal Plain geographic provinces for the purposes of their study. They found the earthquake activity per unit area to be moderately higher in the Piedmont; however, the "a" and "b" values calculated for the two geographic provinces were indistinguishable within their margins of error. Consequently, the Piedmont and Coastal Plain provinces are virtually identical with respect to

recurrence intervals and are considered to be a single seismotectonic province for the purpose of this study.

There has been only one historic event with a Modified Mercalli (MM) intensity of greater than VII in this seismotectonic province--an intensity VII-VIII in the Piedmont of South Carolina in 1913 (Bollinger, 1973A), which is approximately equivalent to a m_b 5.3 event. Based on the apparent absence of paleoliquefaction features along the Coastal Plain (Amick and Gelinas, 1991), it appears that there have been few large events (m_b 5.8 or greater) in the eastern part of the province for at least several thousand years, except in the Charleston region. Consequently, a magnitude of m_b 6.0 is likely to be a prudent estimate of the maximum credible earthquake.

There are no known reports of earthquakes occurring in the Piedmont-Coastal Plain province and being felt in Florida.and the assignment of a minimum magnitude to this province is therefore necessarily subjective. There is a 100 km separation between the zone and the northern border of Florida, which suggests that any event smaller than approximately m_b 5.5 in this province would cause no damage in Florida.

Although there have been several studies of earthquake recurrence in this region, Bollinger et al. (1989) incorporates a comprehensive review of both historic intensity data and instrumental magnitude determinations. From this review, they calculated "a" values of about 2.2 and "b" values of 0.80 for the individual Piedmont and Coastal Plain geographic provinces. The consolidation of the two geographic provinces into a single

seismotectonic province and the subsequent recalculation of Bollinger's figures yields an "a" value of 2.5, while the "b" value, or slope of the regression line, remains unchanged at 0.8. This suggests average recurrence intervals of 32 years for magnitude 5.0 and 200 years for magnitude 6.0 events.

Southern Appalachian Seismotectonic Province

The Southern Appalachian seismotectonic province, which was originally described by Bollinger (1973A), is well-defined on maps of earthquake activity (e.g., Figure 21). This province trends northeastward generally along the topographic apex of the Appalachian Mountains and extends from east-central Mississippi to western Virginia. There has been a significant amount of historic and instrumentally recorded seismic activity along this trend, including seven events with MM intensities greater than VI and an intensity VIII event in Giles County, Virgina, in 1897.

The Giles County event was approximately a magnitude 5.6 event and is one of the largest historic earthquakes to have occurred in the eastern United States. Housner (1969) estimates tectonic settings similar to the Southern Appalachian seismotectonic province to be characterized by maximum credible magnitudes of m_b 7.0. The estimated magnitude of the Giles County event, which is significantly less than Housner's approximation, suggests m_b 7.0 to be a safe upper bound magnitude for this province.

As mentioned, the m_b 6.7 Charleston earthquake caused no appreciable damage in Florida. At their closest boundaries, the Charleston province and Southern Appalachian province are approximately equidistant from Florida. This suggests that the

minimum bound magnitude in the Southern Appalachian province should be equivalent to that assigned to the Charleston province (m_b 6.5).

Based on a compilation of historic and instrumental data, Bollinger et al. (1989) calculated the recurrence relationship for the Southern Appalachian seismotectonic province to be approximated by:

$$\log N_m = 2.67 - 0.82m_{bLg}$$

These values suggest recurrence intervals of 84 years for magnitude 5.6 events and 1175 years for magnitude 7.0 events. These "a" and "b" values are very close to those calculated by Chinnery (1979) from historic intensity data.

New Madrid Seismotectonic Province

In 1811 and 1812, the seismically active Mississippi Valley area experienced three of the largest historic intraplate earthquakes ever documented. These large events had epicentral MM intensities of X-XI, and estimated magnitudes (m_b) ranging from 7.1 to 7.4 (Nuttli, 1973B). Although these events affected most of the eastern United States, they were scarcely felt in northernmost Florida (i.e., MM intensity III). Consequently, it would seem that earthquakes in this province pose little threat to Florida.

Considering the observed magnitudes of these historic events, it is prudent to assign an unusually large maximum credible magnitude to this province. As previously mentioned, only three intraplate earthquakes of magnitude 8 or greater have ever been documented. This probably constrains the maximum credible

magnitude for the New Madrid seismotectonic province to no greater than about m_b 8.3. As suggested by the minimal effects in Florida during the 1811-1812 earthquakes, the minimum significant magnitude for the purposes of this study is m_b 7.4.

The magnitude-recurrence relationship for the New Madrid seismotectonic province was calculated by Nuttli (1974) from historic and instrumental data. The "a" value was found to be approximately 3.55 and the "b" value was calculated to be approximately 0.87. This suggests recurrence intervals of 350 years for m_b 7.0 events and 4700 years for m_b 8.3 events. A later study based on similar data suggested slightly longer intervals (Johnston and Nava, 1985). Subsequent paleoliquefaction studies, as summarized by Rodbell and Schweig (1993), have suggested significantly longer intervals--on the order of 10,000 years for earthquakes greater than m_b 7.0. Thus, it appears that large earthquakes in the Mississippi Valley may not recur in accordance with the logarithmic Gutenberg-Richter relationship. Nevertheless, the use of Nuttli's coefficients provides a margin of safety and will, therefore, be used in this study.

Cayman Trough Seismotectonic Province

A series of distinct seismotectonic features extends along the northern Caribbean plate at its boundary with the North American plate (e.g., Burke et al., 1984; Mann and Burke, 1984; Mattson, 1984). Although the entire plate boundary system is seismically active, the Cayman Trough, because of its proximity to Florida, is the only feature of interest for the purpose of this study. The other features along the plate boundary are too distant, as suggested by the relatively low amplitude of ground motion (approximately 300

microns at 1.2 Hz) recorded at the Everglades seismograph station during a relatively large (m_b 6.9) earthquake in southeastern Cuba on 25 May, 1992.

The Cayman Trough is a distinct, narrow morphological feature extending from off the north coast of Honduras to just west of Hispaniola. The seismicity associated with the trough covers a slightly larger area, as demonstrated in Figure 21 and outlined in Figure 25. Although the 1992 event was not felt in Florida, a destructive earthquake of unknown magnitude near southern Cuba on Jan. 22, 1880 was felt in Key West, suggesting a slight potential for damage from events in this province.

There have been several compilations of seismic activity along the northern Caribbean plate margin (e.g., Sykes and Ewing, 1965; Molnar and Sykes, 1969; Sykes et al., 1982; and Mann and Burke, 1984). These compilations suggest a maximum credible magnitude in the 7.0 to 7.5 range for the Cayman Trough (Ebasco, 1988). Not surprisingly, however, the seismic record is rather limited. The tectonic setting of the trough indicates the potential for significantly larger events--Housner (1969) suggests m_b 8.5 as a maximum credible magnitude for zones proximal to a great fault. Based on the level of ground motion in south Florida during the 1992 earthquake, the minimum significant earthquake in this province is considered to be m_b 7.0.

Ebasco (1988), in a site specific seismic hazard assessment, calculated "a" and "b" values for the Cayman Trough from the previously mentioned compilations of Caribbean earthquakes. These values are 4.58 and 0.93, respectively. This indicates recurrence

intervals of approximately 85 years for m_b 7.0 events and 2100 years for m_b 8.5 events.

CHAPTER 6
SEISMIC ATTENUATION IN THE FLORIDA REGION

Introduction

Seismic attenuation is defined as a reduction in amplitude or energy of a transmitted wave with distance. As it is dependent on the physical characteristics of the transmitting medium, seismic attenuation in the lithosphere may vary by an order of magnitude or more from region to region (e.g., Nuttli, 1973A). This spatial variation accounts for marked differences in the destructive effects of similarly sized earthquakes in different regions. Thus, a local characterization of lithospheric attenuation is a significant factor in accurately assessing seismic hazard at a particular site.

There has been no independent calculation of lithospheric attenuation in Florida. Consequently, local seismic hazard assessments have primarily utilized generalized coefficients for the entire central or eastern United States (e.g., Ebasco, 1988). There is little to substantiate the assumption that attenuation in Florida is comparable to attenuation in other parts of the continent. It is plausible that the allochthonous plateau crust is characterized by inherently different mechanical properties than other regions of the United States. In addition, past studies have suggested that thick sedimentary accumulations, such as in Florida and the Coastal Plain province, act to strongly attenuate seismic energy (e.g., Mitchell and

Hwang, 1987; Chapman et al., 1990). Accordingly, the objective in this chapter is to provide an improved characterization of crustal attenuation in Florida.

Background and Methods

There are two primary factors that contribute to the attenuation of seismic signals: geometric spreading and absorption. While absorption results from several different mechanisms, such as scattering and dispersion, in practice it is neither feasible nor necessary to distinguish between these mechanisms.

Local coefficients for absorption (*a*) are usually calculated from the decay in amplitude (A) of a seismic signal with distance traveled (d) as given by:

$$A(d) = A_0 r^{-n} e^{-ad} \quad \text{(e.g., Howell, 1990)}$$

where "A_0" is the initial amplitude, "r" is the radius of the wave front and "n" is the coefficient of geometric spreading (usually 2 for body waves). Regional values for "*a*" (also referred to as "*y*" in the literature) in the United States typically range from 0.001 km^{-1} to 0.01 km^{-1}, depending on the location and magnitude (e.g., Nuttli, 1980) (Table 1).

Another commonly used term for absorption is "Q", the quality factor. "Q" is related to "*a*" by:

$$Q = \pi f / a\, v$$

where "f" is the frequency and "v" is the velocity of the wave train. An example in the range of values for "Q" (at 1 Hz) in the United

Magnitude		Absorption Coefficient (km^{-1})	
mb	M	Western United States	Central United States
4.0	4.4	- -	.007
4.5	4.9	- -	.006
5.0	5.4	.010	.0045
5.5	5.9	.008	.004
6.0	6.7	.007	.003
6.5	7.5	.0065	.0025
7.0	8.3	.006	.0018

Table 1. Absorption coefficients (*a*) for the western and central United States (Nuttli, 1980; Campbell, 1981).

States is provided by Nuttli (1981), who found "Q" for Love waves to range from approximately 200 in southern California, a value indicative of strong absorption, to approximately 1500 in the central United States, indicating relatively little absorption. "Q" in the eastern United States averages about 900-1000 in the Appalachians, 700-900 along the Atlantic Coastal Plain, and 400-600 in the Gulf Coastal Plain (Singh and Hermann, 1983; Gupta and McLaughlin, 1987; Chapman and Rogers, 1989).

One potential source of error in using amplitude decay to determine absorption arises from the phenomenon that higher frequencies are attenuated more strongly than lower frequencies. In order to minimize this source of error, signals from local earthquakes (or local nuclear blasts) are preferentially utilized over more distant events. This constraint to use local events is countered to some extent by the need for the signal to travel sufficiently far, generally more than 100 km, for the effects of absorption to become significant.

The unique geologic history of the Floridan Plateau suggests that local values of absorption may differ from those assigned to the central and eastern United States. Consequently, in addition to monitoring regional seismic activity, another purpose of the University of Florida Seismograph Network is to allow a discrimination of local values for seismic absorption. Unfortunately, the paucity of local earthquakes and large blasts hinders the process of determining these values. Nevertheless, certain inferences can be made from isoseismal maps of large regional earthquakes, from local ground motion amplitudes resulting from distant events, and from

studies of attenuation in areas with similar thick sedimentary accumulations, such as the southeastern Coastal Plain.

There has been only one earthquake in Florida sufficiently well-documented to contribute to a local study of attenuation--a m_b 4.0 event located about 30 km south of Orlando on Oct. 27, 1973. A Modified Mercalli isoseismal map was subsequently produced by Long (1974), who found the maximum intensity to have been MM intensity V. A method was developed to allow the estimation of a local coefficient of absorption from this isoseismal map.

This method utilizes Campbell's (1981) equation relating peak ground acceleration (PGA), moment magnitude (M), epicentral distance in kms (R), and absorption (*a*) as follows:

$$PGA = 0.0823e^{.922M} (R + 25.7)^{-1.27} e^{-aR}$$

Solving for absorption yields:

$$a = .922M - \ln(PGA/0.0823(R + 25.7)^{-1.27}) / R$$

In order to estimate "*a*" from isoseismal maps, it is necessary to calculate the magnitude and estimate peak ground acceleration at some distance from the epicenter. The relationship between body-wave magnitude and peak intensity was discussed in Chapter 4. As given by Nuttli (1980), moment magnitude (M) is related to body-wave magnitude (m_b) by:

$M = 1.64m_b - 3.16$ (for m_b greater than or equal to 5.59)

or

$$M = 1.02m_b + 0.30 \quad \text{(for } m_b \text{ less than 5.59)}$$

The estimation of peak ground acceleration (in m/s^2) from MM intensity (I) was calculated by Gutenberg and Richter (1956) to be:

$$\log_{10}PGA = (I)/3 - 5/2$$

Essentially, this intensity-absorption method requires the measurement of the mean radius (R) in kms from the epicenter to a well-established isoseismal line, usually MM intensity II or III. Utilizing the mean radius minimizes the biasing effects of differential site response and population distribution. The peak ground acceleration at that mean radius may be approximated from the isoseismal intensity and the Gutenberg-Richter relationship. For example, MM intensity IV is approximately 0.007 g, MM intensity III is about 0.003 g, and MM intensity II is about 0.0015 g. Once the values for magnitude (M), peak ground acceleration (PGA), and radial distance (R) have been established, Campbell's relationship may be used to calculate the absorption coefficient.

Test Cases for Intensity-Absorption Method

Before applying this intensity-absorption method in an assessment of attenuation in Florida, it was necessary to first test it on earthquakes in regions where absorption coefficients have been previously calculated using conventional methods; specifically, the central and western United States. The first test case was the

northern Kentucky earthquake of 27 July, 1980. This earthquake had a magnitude of m_b 5.1, which equates to a moment magnitude (M) of 5.5 (Minsch et al., 1981). As extrapolated from Table 1, the expected absorption coefficient at this magnitude in the central United States is about 0.004 km^{-1}. Figure 26, an isoseismal map of this earthquake, indicates an approximate average radial distance (R) of 445 kms from the epicenter to the edge of the area in which the earthquake was generally felt (MM intensity II). From the Gutenberg-Richter relationship, the peak ground acceleration (PGA) at this isoseismal line is 0.0015 g. By Campbell's relationship, this combination of magnitude, distance, and peak ground acceleration yields an "*a*" coefficient of 0.003 km^{-1}, which is essentially equivalent to the expected value.

The largest test event was a moment magnitude (M) 7.0 earthquake on 28 October, 1983 in central Idaho (Stover, 1987). The USGS isoseismal map for this earthquake is shown in Figure 27. The average radial distance (R) to the most distant isoseismal line is approximately 650 kms. As before, this line represents the distance to a peak ground acceleration of 0.0015 g (MM intensity II), yielding an "*a*" value of 0.003 km^{-1}. As shown in Table 1, this is identical to Nuttli's expected value.

A number of earthquakes were characterized in this manner--some examples are shown in Table 2. In the central and west-central United States, this method produced absorption coefficients that were reasonably close to the expected values in Table 1 despite the potential errors resulting from variable local site responses and population distribution patterns. The calculated absorption

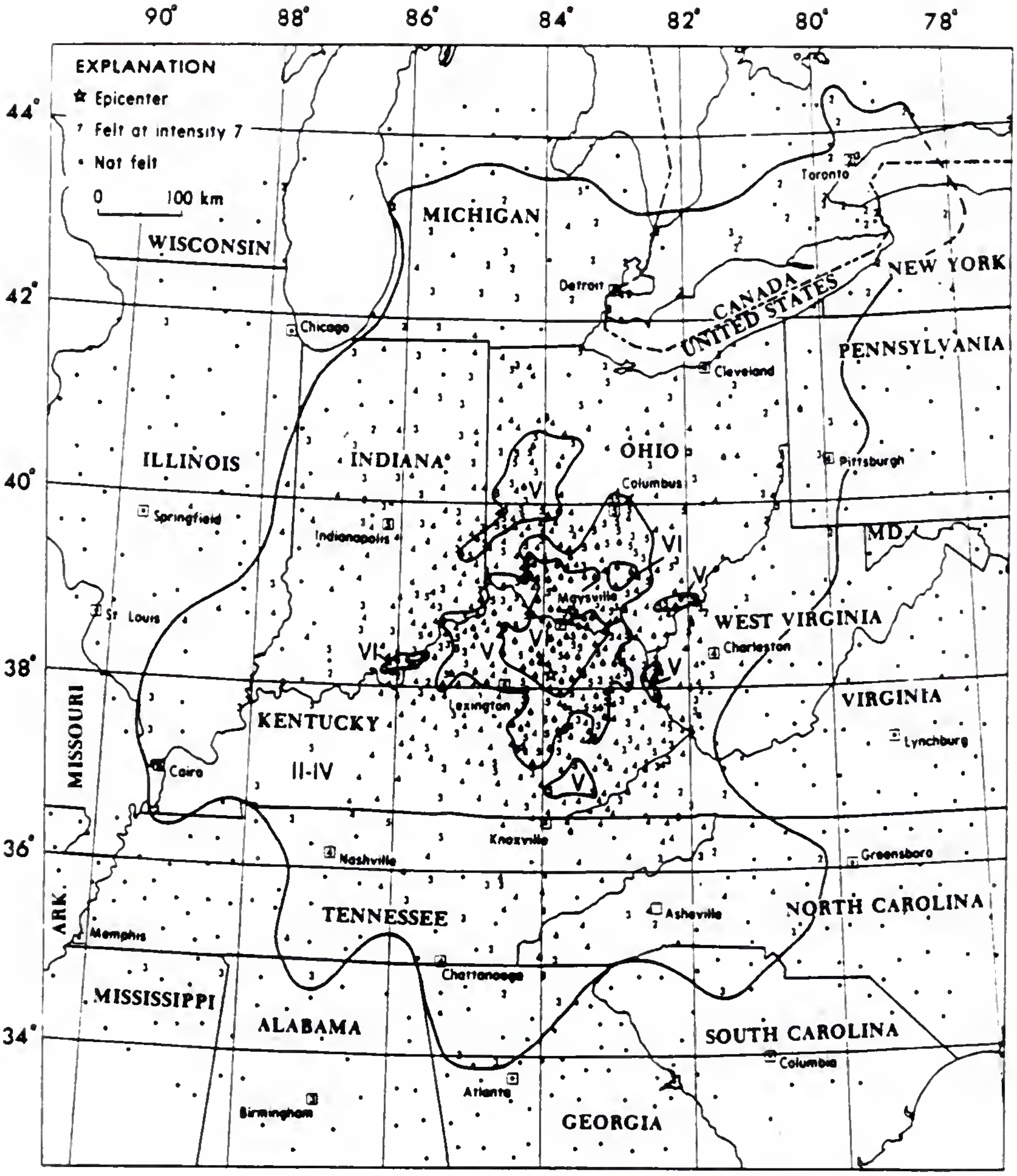


Figure 26. Modified Mercalli intensity isoseismal map for the northern Kentucky earthquake of 27 July, 1980 (from Minsch et al., 1981).

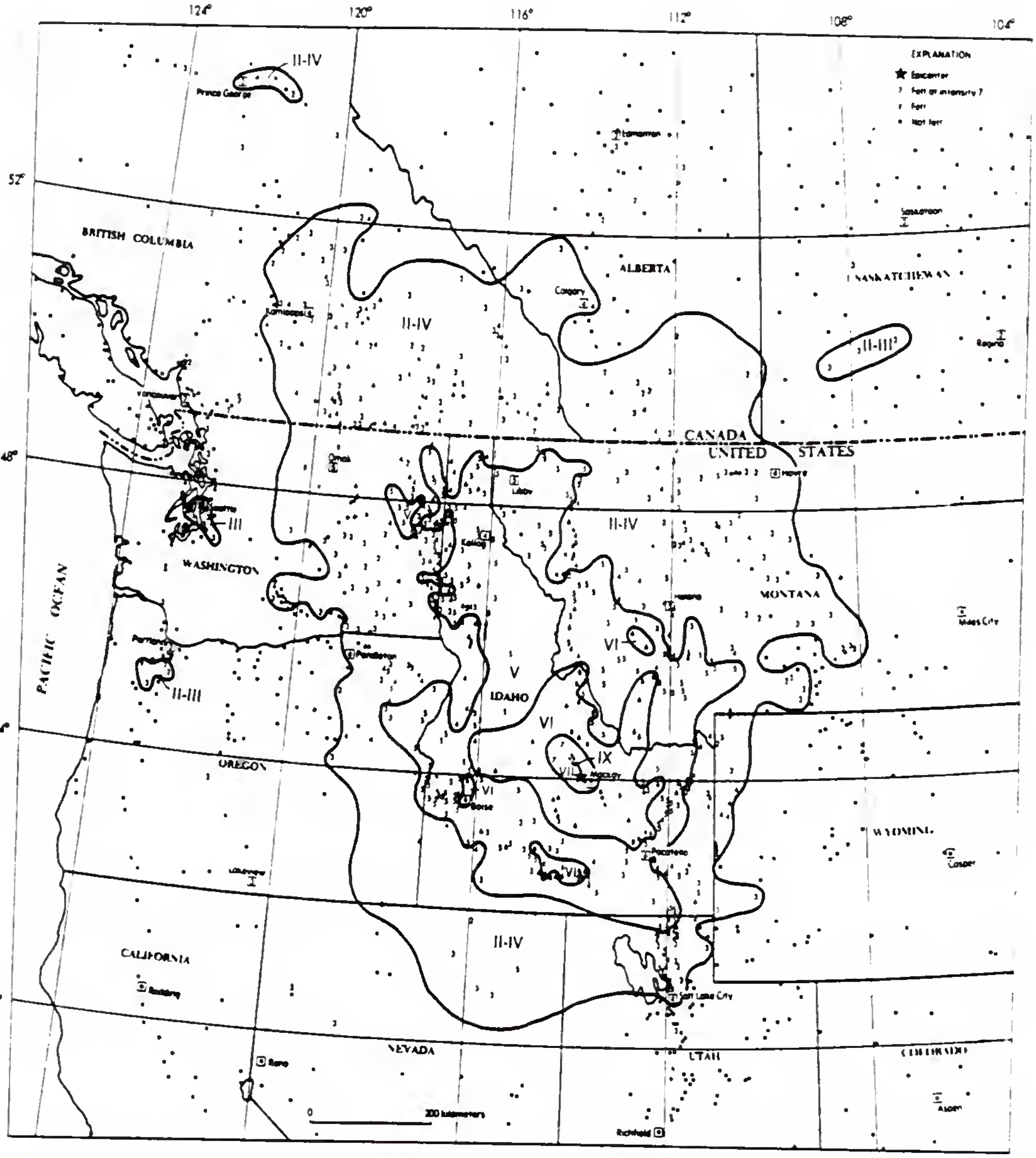


Figure 27. Modified Mercalli intensity isoseismal map for the central Idaho earthquake of 28 October, 1983 (from Stover, 1987).

Location	Reference	Magnitude (M)	Distance (R)	PGA at R	Absorption Coeff.	
					Expected	Calculated
N. Kentucky 27 July 1980	Minach et al. (1981)	5.5	445 km	.0015 g	.004	.003
S. Illinois 10 June 1987	Reagor and Brewer (1987)	5.6	360 km	.0015 g	.004	.004
S. Illinois 9 Nov. 1968	Gordon et al. (1970)	5.7	670 km	.0007 g	.004	.003
S. Illinois 15 May 1983	Stover (1987)	4.2	260 km	.0007 g	.007	.006
N.W. Montana 11 Feb. 1984	Stover (1988)	4.9	250 km	.0015 g	.010	.006
E. Wyoming 18 Oct. 1984	Stover (1988)	5.8	325 km	.0015 g	.008	.006
N.E. Wyoming 29 May 1984	Stover (1988)	5.4	195 km	.0015 g	.010	.011
Central Idaho 22 Aug. 1984	Stover (1988)	5.4	270 km	.0015 g	.010	.008
Central Idaho 28 Oct. 1983	Stover (1987)	7.0	650 km	.0015 g	.003	.003
W. Idaho 27 Nov. 1977	Stover et al. (1979)	4.6	97 km	.0015 g	.014	.022
N. Oregon 13 Apr. 1976	Person et al. (1978)	4.9	130 km	.0015 g	.012	.016
N.W. Washington 16 May 1976	Person et al. (1978)	5.4	155 km	.0015 g	.010	.015
N.W. New Mexico 5 March 1977	Simon et al. (1979)	5.0	130 km	.0015 g	.012	.017
Central Calif. 13 April 1980	Stover et al. (1981)	4.9	105 km	.0015 g	.012	.022
Central Calif. 25 May 1980	Stover et al. (1981)	6.7	280 km	.0015 g	.007	.010
Central Calif. 25 October 1982	Stover (1985)	5.7	135 km	.0015 g	.009	.021
Central Calif. 23 Jan. 1984	Stover (1988)	5.5	110 km	.003 g	.010	.019
S. California 26 April 1981	Stover et al. (1982)	5.9	225 km	.0015 g	.008	.011
S. California 15 June 1982	Reagor et al. (1983)	4.9	115 km	.0015 g	.012	.019

Table 2. Parameters and resultant estimated absorption coefficients for various earthquakes, as grouped by region. Expected coefficients are from Table 1 and calculated coefficients were derived using the methods described in the text.

coefficients in California and the Pacific northwest were consistently higher than the expected regional values. This locally high seismic attenuation has been previously observed (Nuttli, 1981; Singh and Hermann, 1983) and probably results from wave scattering in the heavily fractured lithosphere proximal to the tectonically active plate boundary (e.g., Pulli and Aki, 1981). Consequently, despite these locally high values, it appears that all of the results are generally consistent with previous observations, indicating this to be a viable method for estimating absorption coefficients from isoseismal maps.

Results from the Florida Region

The calculation of an absorption coefficient for the wavefront path between the Charleston seismotectonic province and Florida is vital for accurately assessing seismic hazard in Florida. Consequently, the intensity-absorption method was applied to the 1886 Charleston earthquake, which is estimated to have been a magnitude m_b 6.7 (M 7.8) event (Bollinger, 1977). Bollinger's MM intensity isoseismal map is shown in Figure 28.

An absorption coefficient was first calculated in a west to northwest direction from the epicenter, perpendicular to the Appalachian regional trend. The average radial distance to a peak intensity of IV, which equates to a peak ground acceleration of 0.007 g, is approximately 510 kms. These values yield an "*a*" value of 0.0033 km^{-1}, which is slightly higher than expected values for the central United States, but significantly lower than comparable absorption coefficients in the western United States (e.g., Table 1). For an assumed frequency of 1 Hz and a wavetrain velocity of 3

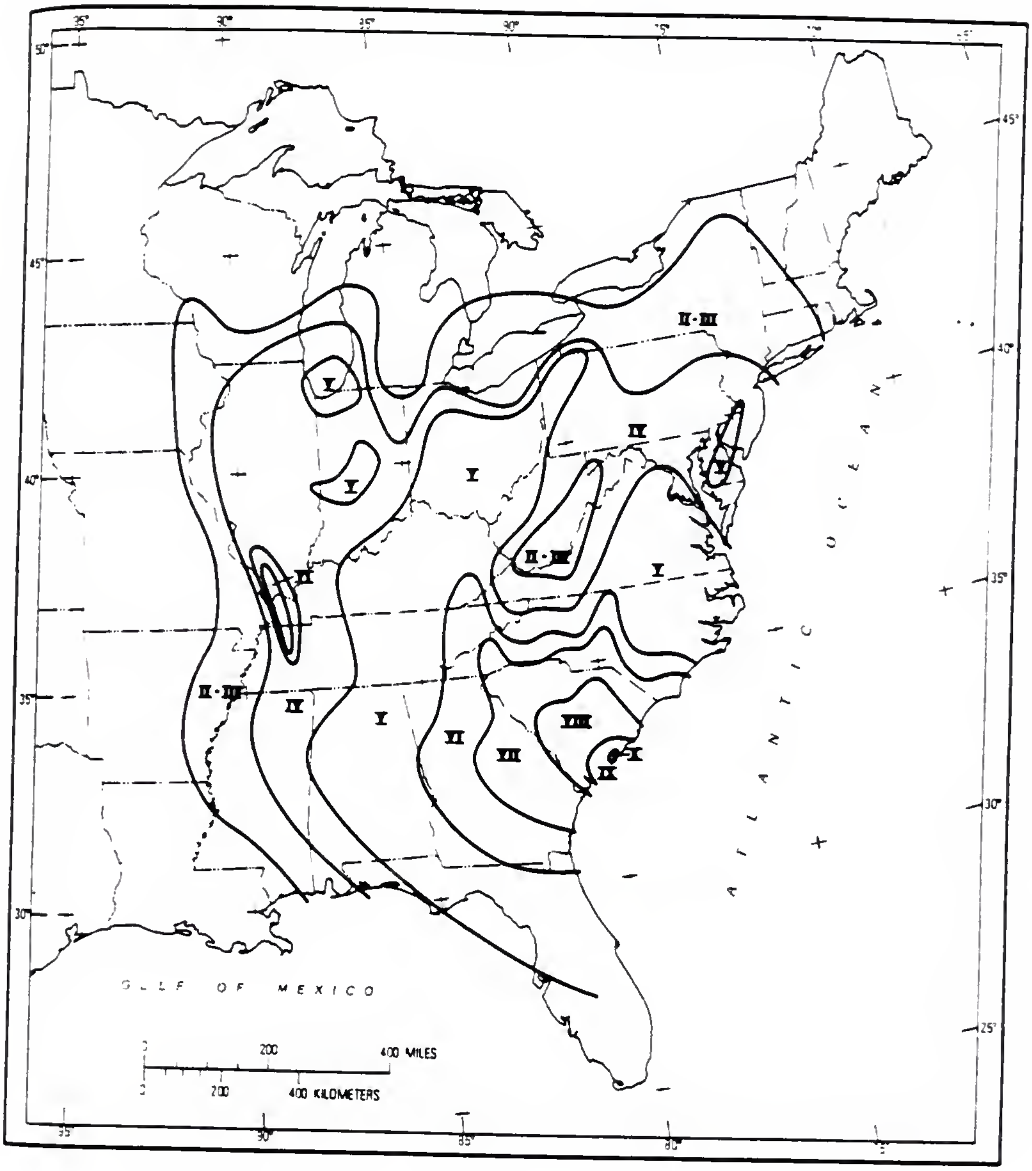


Figure 28. Modified Mercalli intensity isoseismal map for the 1886 Charleston earthquake (from Bollinger, 1977).

km/sec, this equates to a Q value of 317. Although this is moderately lower than has been obtained in other studies of Q in the eastern United States (e.g., Singh and Hermann, 1983; Gupta and McLaughlin, 1987; Chapman and Rogers, 1989), this is almost certainly attributable to the high moment of the event and its Coastal Plain origin.

The absorption coefficient was then calculated in a southwesterly direction from the epicenter, encompassing the Coastal Plain region between Charleston and Florida. The average distance to MM intensity V (PGA 0.015 g) in this direction is 360 kms. This yields an absorption coefficient of 0.0037 km^{-1}. Alternatively, the average distance to MM intensity IV (PGA 0.007 g) may also be used. This is about 580 kms and yields a slightly lower "*a*" coefficient, 0.0026 km^{-1}.

The low population density of central Florida (e.g., Fernald, 1981) during the 1880's suggests that the intensity IV isoseismal line is probably less accurate than the intensity V line, which extended through the more densely populated coastal areas (Figure 28). Thus, the 0.0026 km^{-1} value is suspect. An average value of 0.0032 km^{-1} likely represents a conservative value for the purposes of seismic hazard assessment. Assuming, as before, a frequency of 1 Hz and a wavetrain velocity of 3 km/s, this value equates to a Q of 327. An absorption coefficient of 0.0032 km^{-1} for a magnitude (M) 7.8 event is essentially the same as was calculated across the Appalachian trend and represents a moderately higher attenuation than in the central United States, but significantly lower than the average western United States values (Table 1). This corresponds

closely to preliminary absorption coefficients calculated from University of Florida seismograms of recent earthquakes in the southern Appalachians (Bellini et al., 1993).

The intensity-absorption method was then applied to the the Oct. 27, 1973, Florida earthquake. This earthquake had an approximate body-wave magnitude of 4.0 (Long, 1974), which is equivalent to a moment magnitude (M) of 4.4. An isoseismal map of this earthquake is shown in Figure 29. The average radial distance (R) to the MM intensity II (PGA 0.0015 g) isoseismal line is 130 kms. This suggests an absorption coefficient of 0.0127 km^{-1}. It should be noted, however, that Long's magnitude calculation had a possible error range of 0.6 m_b units, suggesting a potential range of 0.0104 km^{-1} to 0.0147 km^{-1} for "*a*". Even within this range, a comparison with the equivalent absorption-magnitude values in Table 1 again suggests a moderately higher attenuation in the Florida region than in the central United States.

A further application of this method is that minimum absorption coefficients may be calculated without using isoseismal maps. For example, the m_b 6.9 (M 8.16) earthquake in southeastern Cuba on 25 May, 1992 was not felt in Florida. This suggests a maximum MM intensity of II, or a peak ground acceleration of no more than 0.0015 g, in southernmost Florida. The epicentral distance to the southern tip of Florida is approximately 775 kms. Using these values as M, PGA, and R, respectively, allows the calculation of a minimum value for "*a*". Considering the significant thickness of the sedimentary accumulations and the presence of the intercedent Straits of Florida along this wave path, a relatively high absorption

Figure 29. Modified Mercalli intensity map for the Florida earthquake of 27 October, 1973 (after Long, 1974).

coefficient would be expected. In this case, the calculated minimum "*a*" is 0.0039 km^{-1}.

From Table 1, this value represents an average of the values from the central and western United States and, as expected, is moderately higher relative to the other calculated absorption values in the Florida region. Although this minimum value seems intuitively reasonable, it is possible that the actual value is significantly higher.

Thus, seismic attenuation on the Floridan Plateau and the adjacent regions of North America appears to be slightly higher than attenuation in the central United States, but significantly less than in the western United States. Despite the allochthonous origin of the plateau basement, this is consistent with other indicators of attenuation in the eastern United States. Furthermore, attenuation along the wave path between the Cayman Trough seismotectonic province and Florida appears to be at least moderately higher than attenuation in the eastern continental United States, and may be significantly higher.

CHAPTER 7
SEISMIC HAZARD IN FLORIDA

Introduction

There is a specific sequence of steps necessary for the probabilistic assessment of seismic hazard at sites with historically low levels of seismic activity (Cornell, 1968; Yegian, 1979; Reiter, 1990). These steps include characterizations of the tectonic history and geologic setting of the site (e.g., Chapters 2 and 3), an analysis of the regional distribution of seismic activity (Chapter 4), the partitioning of the region into seismotectonic provinces and the quantification of the potential levels of seismicity in each province (Chapter 5), and a quantification of seismic attenuation (Chapter 6). In this chapter, the intention is to present an empirical assessment of seismic hazard in Florida based on the results given in the previous chapters.

Methods

The empirical determination of seismic hazard at a given site is founded on a method suggested by Cornell (1968). This determination is accomplished by calculating the probability that earthquake activity from a seismotectonic source or province will produce a certain acceleration at the site of interest within a given time period, usually one year. The calculation of this probability utilizes the magnitude distribution at the source, the distance

between the source and the site, and the attenuation along the wave path. It is repeated for each of "N" significant seismotectonic sources or provinces over a range of accelerations. The probability per year of exceeding a particular acceleration ($P[A > a]$) at the site is then the summation of the individual probabilities calculated for each source or province as given by:

$$P[A>a] = 1-e^{-\sum_{i=1}^{N} \lambda_i(a)}$$

where $\lambda_i(a)$ represents the annual mean number of events producing an acceleration greater than "a" due to source "i".

There are several programs available for this type of seismic hazard assessment. The one selected for this study is SEISRISK III, which was developed by the USGS (Bender and Perkins, 1987). In order to use SEISRISK III, it is necessary to construct an input file containing a table of magnitudes, distances, and accelerations for the calculation of attenuation, as well as source and site locations, and source magnitude-recurrence characterizations. One of the input files constructed for this study is shown in Figure 30.

The first significant step in the construction of the input file was to develop a table relating peak ground accelerations at various magnitudes and epicentral distances for the Florida region. Because absorption coefficients in Florida are very close to those in the remainder of the southeastern Coastal Plain, the isoseismal map for the m_b 6.7 (est.) 1886 Charleston event (Figure 28) was used to construct the first column of values in the table. Using the methods described in Chapter 6, the peak acceleration at each of the

```
Peninsular Florida Seismic Hazard
0 0
.99 3 1 50 100
1. 0 .5 0
87.0 28.0 80.0 28.0
87.0 31.15 80.0 25.0 .5982 .6240
1 11 7 11
0
3 5
Fla-Region     6.7      5.5      4.0
80.0           .15      .0345    .007
130.0          .05      .0164    .0015
240.0          .03      .0048    .00026
360.0          .015     .00164   .00003
580.0          .007     .0003    .00001
00 1.00        -1            Char
2 1 1
82.30 33.10 81.30 34.30
81.00 32.10 79.70 33.50
.0001 .0003 .0005
7.40   7.00   6.50
00 1.00        -1            Pied
3 1 1
80.30 37.50 77.00 37.50
82.00 36.00 77.00 36.00
87.00 32.00 79.70 32.00
.0050 .0072 .0125
6.000 5.800 5.500
00 1.00        -1            SApp
2 1 1
82.80 37.50 80.30 37.50
88.50 32.00 87.00 32.00
.0008 .0012 .0022
7.000 6.800 6.500
00 1.00        -1            NMad
2 1 1
87.40 38.00 86.00 38.00
90.30 35.30 88.00 35.30
.0002 .0006 .0013
8.300 7.800 7.400
00 1.00        -1            Caym
2 1 1
86.70 18.50 77.00 20.70
86.70 17.00 77.00 17.00
.0005 .0014 .0040 .0117
8.500 8.000 7.500 7.000
00 1.00        +2            Flor
3 1 1
90.00 32.00 77.00 32.00
90.00 22.00 77.00 22.00
86.00 18.70 77.00 20.70
.0140 .0234 .0389 .0646
5.000 4.600 4.200 3.800
99
```

Figure 30. The SEISRISK III input file for the calculation of seismic hazard in peninsular Florida using the format described in Bender and Perkins (1987).

isoseismal lines was estimated and an appropriate distance measured. Similarly, the isoseismal map for the 1973 Florida earthquake (Figure 29) was used as well. The limited felt area (the area covering MM intensity III effects or greater) of this small (m_b 4.0) event necessitated the calculation of a peak ground acceleration at the appropriate distances by using Campbell's relationship (Chapter 6) and an absorption coefficent of 0.0127 km^{-1}. The table was completed by calculating accelerations at the appropriate distances for a hypothetical m_b 5.5 event using an extrapolated absorption coefficient of 0.005 km^{-1}. The completed table starts on the 10th line of Figure 30 and is labeled "Fla-Region".

The next significant step in the construction of the input file was to produce tables characterizing the locations and magnitude-recurrence relationships of each of the seismotectonic provinces described in Chapter 5. These tables start on line 16 of Figure 30 with the Charleston seismotectonic province, which is labeled "Char". The significant elements in these tables are the longitudes and latitudes of the corners of the provinces and the recurrence intervals for the appropriate ranges of magnitudes. These recurrence intervals were calculated from the individual "a" and "b" values for each province as assigned in Chapter 5.

The inherent uncertainty concerning source parameters and propogation paths in any seismic hazard model is addressed by the introduction of a variable, sigma. In empirical calculations, sigma is the standard deviation of the natural logarithm of the expected acceleration at the site of interest. The utilization of this variable is intended to account for possible errors and consequently, always acts

to increase the calculated hazard probability at the site. Bernreuter et al. (1989) suggested that appropriate values for sigma range from 0.35 to 0.70. Therefore, in this study, sigma was assigned a value of 0.5. Although the probabilities shown in the hazard maps reflect this value for sigma, probabilities calculated without this margin of error (sigma = 0.0) were also calculated and are given in the Appendix.

Two separate input files were run--one to cover peninsular Florida and another for the Florida panhandle region. The seismic hazard probabilities were calculated on grids with spacings of 67 kms. The output files, with each site's latitude, longitude, and hazard probabilities over a range of accelerations for sigma = 0.0 and sigma = 0.5, may be found in the Appendix. The two gridded data sets were combined for input into Surfer, a contouring program. This contoured output was subsequently used as the foundation for two probabilistic seismic hazard maps describing the probabilities of exceeding accelerations of 0.02 g and 0.08 g, respectively, in the state of Florida.

Results

For each of the input parameters, values were assigned to maximumize the calculated seismic hazard probabilities in Florida. For example, each of the seismotectonic sources were assigned maximum credible magnitudes significantly greater than the observed maximum magnitudes. In addition, a single attenuation function was used. While this attenuation function is probably a reasonable approximation of attenuation in the southeastern Coastal Plain, it is almost certainly too low for the oceanic wave path (along

which surface waves do not propagate) between Florida and the Cayman Trough. Consequently, the calculated contribution to seismic hazard in Florida from activity in the Cayman Trough province is probably too high. Finally, in those provinces where there are contradicting indicators of recurrence, such as in the New Madrid province, the shortest recurrence interval was used.

The probability of exceeding 0.08 g (MM intensity VII) is greatest in the northwestern corner of Florida (Figure 31). Annual probabilities range from 2.6×10^{-4} at this northwestern corner to 6.0×10^{-5} in southern peninsular Florida. This suggests recurrence intervals for MM intensity VII effects ranging from 3850 years in northwestern Florida to 16,700 years in southern Florida. Similarly, the annual probability of exceeding 0.02 g (MM intensity V-VI) is greatest in northwestern Florida and least in southern Florida (Figure 32). Although the probability distribution is similar, the probabilities of exceeding 0.02 g are about one order of magnitude higher. These range from 2.6×10^{-3} along Florida's northwestern border to 8.0×10^{-4} in southwestern Florida, suggesting recurrence intervals of 385 years and 1250 years, respectively.

Significant damage (i.e., damage to reasonably well-constructed buildings) is only likely to result from accelerations greater than 0.2 g. This is approximately equivalent to MM intensity VIII. For very well-engineered structures, such as nuclear reactor cores, damage is unlikely by accelerations of less than 0.3 g (e.g., Khoury and Chandra, 1989). The probabilities listed in the output of SEISRISK III are given to five decimel places (i.e., the minimum listed value is 1.0×10^{-5}). In northwest corner of the Florida panhandle, the probability

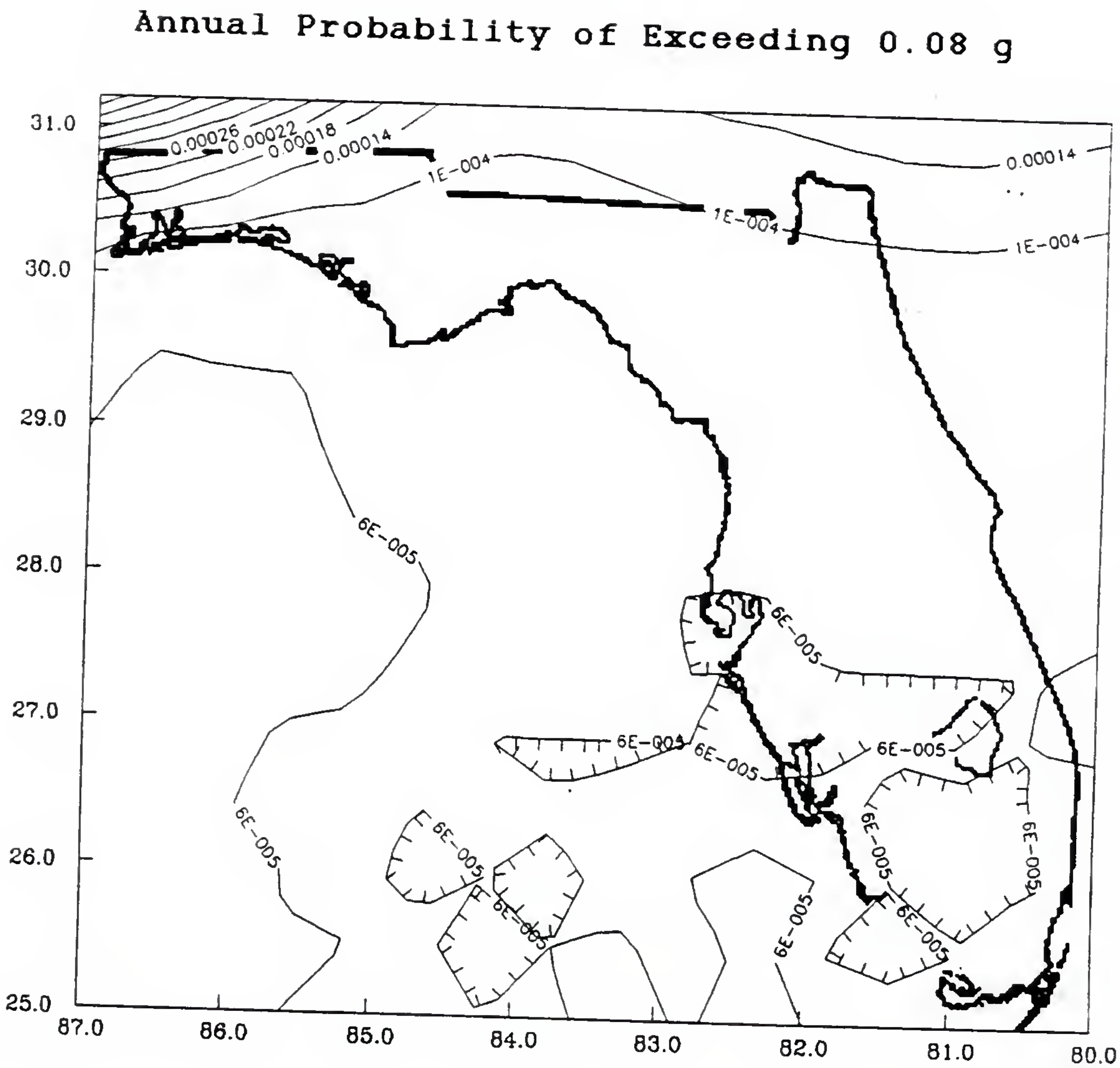


Figure 31. The distribution of annual probabilities of exceeding 0.08 g in Florida.

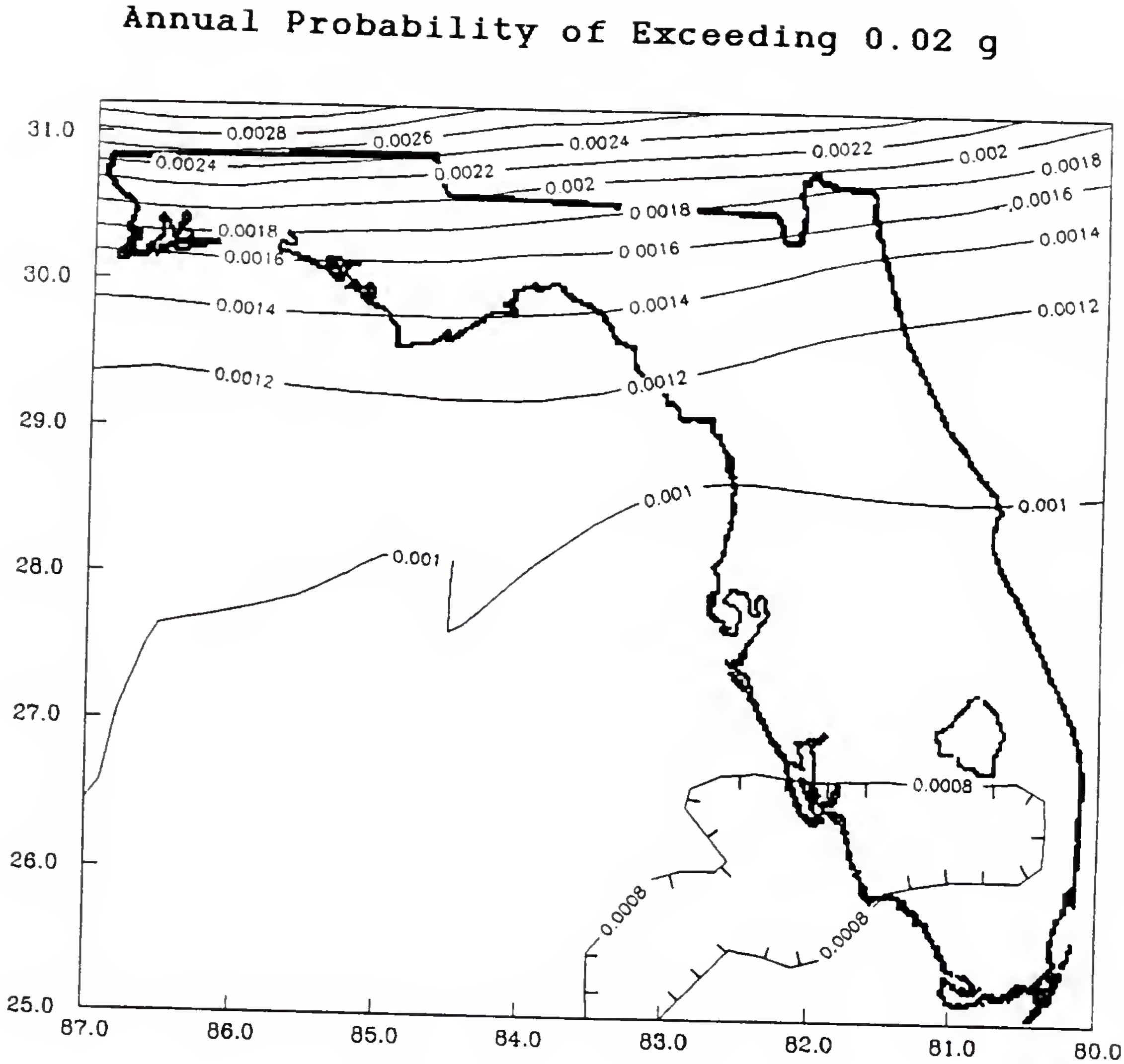


Figure 32. The distribution of annual probabilities of exceeding 0.02 g in Florida.

of exceeding 0.3 g is 2.0×10^{-5}/year, however, in the majority of the state, the probability is less than the minimum value of 1.0×10^{-5} per year. The maximum calculated probability of exceeding 0.2 g, which is also in the northwestern corner of the panhandle region, is 8.0×10^{-5}/year. For the majority of Florida, the annual probability of exceeding 0.2 g is less than 1.0×10^{-5}.

In assessments of seismic hazard at the Turkey Point and St. Lucie nuclear power plants in south Florida, Ebasco (1988) found the annual probability of exceeding 0.3 g to be approximately 1.0×10^{-6} (averaged from both sites). This is an order of magnitude lower than the previous Nuclear Regulatory Commission (NRC) estimates of 1.2×10^{-5} and below the designated NRC safety level of 1.0×10^{-5} (Khoury and Chandra, 1989). While the calculated probabilities of exceeding 0.3 g at these sites are too low for the assignment of specific values using SEISRISK III, it is apparent that, as suggested in the Ebasco study, the annual probability of exceeding 0.3 g in south Florida is significantly lower than the average 1.2×10^{-5} value estimated by the NRC.

Thus, despite the utilization of maximum values for magnitudes and minimum values for recurrence intervals and attenuation, the calculated annual probability of significant earthquake damage in Florida is very low--lower than the minimum value calculated in SEISRISK III throughout most of the state. The greatest seismic hazard is in the northwestern corner of the state, where the recurrence interval for strong ground motion (greater than 0.2 g) is approximately 12,500 years.

CHAPTER 8
DISCUSSION AND CONCLUSIONS

Introduction

In this study, seismological and potential-field data have been utilized with a variety of disparate previously published geophysical, geochemical, geological, and historical information to provide integrated analyses of the basement structure, potential seismicity, and seismic attenuation of Florida, as well as the nature and distribution of seismicity in the southeastern United States and the northern Caribbean. The purposes for this are to generate an improved model for the tectonic evolution of the Floridan Plateau and to allow an empirical assessment of seismic hazard in Florida.

Discussion

The configuration of the lithotectonic units and structural features characterizing the basement of the Floridan Plateau documents a complex and active history during much of the Phanerozoic. The predominant structural feaure of the Floridan Plateau is the Jay Fault zone, which may be contiguous with the Bahamas Fracture zone. The fault zone is a continuous and relatively linear feature that bisects the plateau and acts as a boundary for a number of basement features and units. In southeastern Florida and probably along its entire length, the Jay Fault zone consists of a

parallel series of faults which have served to accommodate a variety of relative movements.

The Jay Fault zone may have originated as a right-lateral transform during the Late Paleozoic closure of Gondwana with Laurentia (Smith, 1993). This origin could account for the presence of isolated and probable fault-bounded Gondwanan terrane fragments in northeastern Florida, the truncation of those fragments along a linear boundary, and the presence of another probable Gondwanan fragment, the Catoche terrane, in the eastern Gulf of Mexico.

During the Middle Mesozoic, the Jay Fault zone was reactivated to accommodate left-lateral motion resulting from differential attenuation of the crust during the separation of North and South America and the opening of the Gulf of Mexico. The continental crust to the southwest of the Jay Fault zone stretched and subsided while the plateau crust to the northeast of the Jay Fault zone was largely unaffected. In addition to accomodating the left-lateral motion which would result from extension along only one edge, the Jay Fault zone also experienced down-to-the-southwest normal faulting along some segments as a series of large grabens and half-grabens formed across the southwestern half of the Floridan Plateau in response to this crustal extension. Despite the active role of the Jay Fault during the Jurassic, the continental nature of the crust in the southwestern half of the plateau suggests that it did not act as the southern boundary of North America, as has been previously suggested (Klitgord et al., 1984).

In the digitally filtered gravity anomaly maps produced for this study and in the numerous previously published seismic reflection profiles reviewed, no evidence was found for the Florida Elbow Fault. This is a hypothesized transform fault, which would necessarily extend across the southwestern quarter of the Floridan Plateau, along which the crustal block presently underlying the Florida Straits was proposed to have moved out of the eastern Gulf of Mexico during the Jurassic (Pindell, 1985). Because there is no evidence for this fault, it is suggested that the eastern Gulf of Mexico was occupied by continental crust during the Early Mesozoic and that this crust has been attenuated and subsided. During this process of attenuation and subsidence, a series of grabens, half-grabens and horsts formed along the southwestern half of the Floridan Plateau.

There have been several previously proposed configurations for these horsts and grabens, which now form the basins and arches of the southwestern plateau basement. These various configurations are based primarily on seismic reflection profiles, which are restricted by their two-dimensional nature. The application of an upward-continuation digital filter to the Bouguer gravity anomaly field of the plateau reveals that these basins and arches are clearly delineated by long-wavelength gravity anomaly patterns.

When interpreted in conjunction with previously published seismic reflection profiles and drill hole information, there are several significant conclusions that may be derived from these anomaly patterns. The first is that the Tampa Basin extends eastward to the Jay Fault zone and is therefore larger than previously believed. In addition, unlike the boundaries of the other

Jurassic features in this series, the northwestern boundary of the Tampa Basin is a sloping margin that does not appear to be marked by a bounding fault, which suggests that the basin formed as a half-graben.

The South Florida Basin region, where there are few seismic reflection profiles imaging the basement, probably encompasses two or three separate basins which trend northwestward, perpendicular to the trends of the Apalachicola Basin, the Middle Ground Arch, the Tampa Basin, and the Sarasota Arch. The orientations of these various basins suggest two distinct episodes of crustal attenuation on the Floridan Plateau, one in which the minimum principal stress direction was oriented northeast-southwest (present direction) and one in which the minimum principal stress was oriented northwest-southeast. It is likely that during the Early Jurassic, the terrane under south Florida was located more to the northwest, proximal to the eastern Gulf of Mexico, and it is surmised that the northwest-trending basins formed during a period of northeast-southwest extension as the Yucatan block rotated away from the Floridan Plateau block. The northeast-trending horsts and grabens subsequently formed during a period of northwest-southeast extension as North and South America separated.

Thus, the Paleozoic convergence and Mesozoic divergence of the continents caused a significant amount of brittle deformation and translocation of terrane fragments in the Floridan Plateau basement. Despite the resultant presence of numerous potential zones of crustal weakness in the basement, the undisturbed sedimentary accumulations overlying the basement document an extended period

of tectonic quiescence. This tectonically quiescent period, characterized only by subsidence, has persisted since at least the Middle Cretaceous. The primary significance of this period of quiescence is the suggestion that the Floridan Plateau is relatively aseismic. This suggestion is further substantiated by the unusually low levels of historical and instrumentally recorded seismic activity in Florida, as discussed below.

A compilation and review of epicentral distribution patterns in the southeastern United States demonstrates there to be distinct patterns of earthquake activity. In addition, there appears to be a well-defined seismotectonic boundary between the moderate-to-high levels of seismic activity in the southern Appalachians and Coastal Plain to the north and the unusually low level of seismic activity on the Floridan Plateau to the south. This seismotectonic boundary corresponds to the previously proposed trace of the Alleghenian suture between the Gondwanan terranes underlying Florida and the accreted terranes of the southern Appalachian orogen (Chowns and Williams, 1983; Nelson et al., 1985A).

This nonuniform distribution of seismic activity can be used as a means of interpreting possible causal mechanisms of seismic activity in the intraplate setting of the southeastern United States. For example, preferential earthquake activity along pre-existing, shallow crustal, Mesozoic zones of weakness has been hypothesized as one possible cause of the nonuniform epicentral distribution in the eastern United States (e.g., Sbar and Sykes, 1973: Sykes, 1978). Similar features throughout the basement of the Floridan Plateau

show no indication of seismic activity during the Cenozoic, suggesting that this is probably not a viable hypothesis.

The regional stress field in the eastern United States has recently been found to be relatively uniform with respect to magnitude and orientation (Zoback, 1992). Because the nonuniform distribution of earthquakes is, therefore, unlikely to be related to changes in the regional stress field, it is probably attributable primarily to the distribution of optimally oriented and positioned seismotectonic features. Recent focal plane solutions show the majority of earthquakes to be caused by the regional stress field and to occur in the autochthonous Grenvillian basement below the Appalachian detachment (e.g., Bollinger et al., 1985; Johnston et al., 1985; Zoback, 1992).

This suggests reactivated Iapetan faults or other pre-existing features in the Grenvillian crust as primary seismic source zones in the southeastern United States. The presence of the observed seismic-aseismic boundary separating the Floridan Plateau from the remainder of North America supports this model, as this boundary also marks the southern boundary of Grenvillian crust. Thus, the observed low level of seismic activity in Florida is probably related to an absence of similar mid-crustal zones of weakness.

The reactivation of a given pre-existing fault probably depends on several different factors. The most critical is likely to be the orientation of the fault with respect to the stress field. Another is likely to be the propensity for fault slippage, which is affected by both hydrostatic pore pressure and the frictional coefficient of the fault. Thus, variations in fault orientation, pore pressure, and

frictional coefficients may each affect the distribution of earthquakes in the southeastern United States as well.

For the purposes of seismic hazard assessment, it is necessary to divide the region into a number of seismotectonic provinces, each characterized by a uniform potential for earthquakes throughout. Although previous attempts have been made to characterize known shallow crustal geographic or geologic provinces as seismotectonic provinces, the recent recognition that most of the earthquake activity in the southeastern United States occurs at mid-crustal depths negates these attempts. Rather, the characterization of seismotectonic provinces in this area is most reasonably based only on observed earthquake distribution patterns.

For the objective of assessing seismic hazard in Florida, five significant seismotectonic provinces were identified in the southeastern United States. In addition to the region encompassing Florida, these include the Charleston province, the Piedmont-Coastal Plain province, the southern Appalachian province, and the New Madrid province. In the northern Caribbean, only earthquake activity in the Cayman Trough province could potentially cause significant ground motion in Florida.

Recurrence intervals and maximum magnitudes assigned to most of the provinces were based on tectonic setting, previously published compilations of earthquake reports, and paleoseismic evidence. In addition, the seismicity of the Floridan Plateau region was investigated in greater detail. A critical review of earthquake reports in Florida (Smith and Randazzo, 1989) suggested only six possible historical events--all of these were low intensity and one

has since been assigned a South Carolinian origin. A review of reports from the Southeastern United States Seismograph Network (SEUSSN), which has been operational since 1977, revealed no evidence of activity on the Florida Plateau and only one event in the central or eastern Gulf of Mexico.

Although these instrumental and historical reports demonstrate the low level of seismic activity on the Floridan Plateau, they may be attributable in part to the distribution of the SEUSSN seismograph stations, none of which were located in Florida, and to the low population of Florida prior to this century. Consequently, a network of digital seismographs was emplaced across Florida in 1989 to allow a specific quantification of microearthquake activity on the Floridan Plateau, in the eastern Gulf of Mexico, and in the Bahamas. From 1989 to 1993, the network detected only two events in this region--both were low magnitude events located in the eastern Gulf of Mexico.

Based on the review of historical and instrumental records and the findings of the Florida Seismograph Network, the seismotectonic province encompassing the Floridan Plateau, the eastern Gulf of Mexico, and the western Bahamas was assigned a maximum magnitude of m_b 5.0. There were too few events to allow a calculation of specific recurrence intervals, so for the purposes of seismic hazard assessment, they were estimated to be 70 years for a magnitude m_b 5.0 event and 20 years for a magnitude m_b 4.0 event.

In addition to the characterization of seismotectonic provinces, it is necessary in any seismic hazard assessment to establish a regional value for seismic attenuation. This value describes the

ability of the lithosphere to transmit seismic energy and is usually calculated using the wave amplitudes or accelerations resulting from local earthquakes. As there have been few earthquakes in Florida, there has been no previous calculation of a local value for seismic attenuation.

Seismic attenuation results from two effects: geometric spreading and absorption. Absorption coefficients can vary by about an order of magnitude from one place to another. A method allowing the estimation of absorption coefficients using earthquake isoseismal intensity data was devised using Campbell's (1981) equation relating magnitude, distance, and acceleration.

This method was used to estimate absorption along the wave path between South Carolina and Florida using Bollinger's (1977) isoseismal intensity data for the m_b 6.8 (estimated) 1886 Charleston earthquake. In addition, the method was applied to the isoseismal intensity data from Long's (1974) study of the m_b 4.0 in central Florida on Oct. 27, 1973. In both cases, the estimated absorption coefficients (0.0032 km^{-1} and 0.0127 km^{-1}, respectively) were slightly higher than Nuttli's (1980) regional absorption coefficients for similar magnitude events in the central United States, but lower than expected equivalent values in the western United States.

The partitioning of the southeastern United States region into seismotectonic provinces, the quantification of seismic activity in each province, and the quantification of local values to describe seismic attenuation allows an empirical assessment of seismic hazard in Florida. The probabilities of exceeding discrete levels of ground motion at a grid of sites covering the entire state were calculated

using SEISRISK III, a USGS program based on a method proposed by Cornell (1968) and written by Bender and Perkins (1987).

Although seismic hazard throughout Florida was found to be extremely low, the greatest probabilities for significant ground motion were found to exist in the northwestern corner of the state. These probabilities decrease significantly southward along the axis of the peninsula. For example, the probability of exceeding 0.2 g, which is approximately equivalent to MM intensity VIII and the acceleration above which significant damage starts to occur, is calculated to be 8.0×10^{-5}/year in the northwestern corner of the state. This indicates a recurrence interval of approximately 12,500 years. Throughout the majority of Florida, however, the probability of exceeding 0.2 g is significantly less than 1.0×10^{-5}/year, suggesting recurrence intervals of greater than 100,000 years. Similarly, the annual probabilities of exceeding 0.08 g (MM intensity VII) range from 2.6×10^{-4} in the northwestern corner of the state to 6.0×10^{-5} in southern Florida, suggesting recurrence intervals of 3850 years and 16,700 years, respectively.

The undisturbed sedimentary record of the Floridan Plateau, the intraplate tectonic setting, historical records, and instrumental monitoring all suggest the region to be tectonically quiescent. Although small earthquakes are to be expected, there appears to be little potential for damaging earthquake activity on the plateau. In addition, the empirical assessment of seismic hazard in Florida suggests only a minimal annual probability of significant ground motion in Florida resulting from earthquakes in adjacent provinces.

Thus, the overall potential for damaging ground motion in Florida is considered to be negligible.

Conclusions

This investigation incorporated a diverse variety of information and, as a consequence, a number of conclusions may be drawn. The most significant of these conclusions are related to the basement structure, tectonic history, and seismic hazard of the Floridan Plateau.

The Late Precambrian-Early Paleozoic terranes underlying the northeastern portion of the Floridan Plateau probably represent isolated, fault-bounded fragments of larger terranes. As has been previously suggested, these fragments likely originated along the leading edge of Gondwana proximal to the central Rockelide orogen. The configuration of these fragments, their proximity to each other, and their apparent truncation by the Jay Fault zone each support Smith's (1993) hypothesis of translocation and emplacement during the Late Paleozoic convergence of the continents.

The configuration of the basins and arches underlying the southwestern half of the Floridan Plateau is clearly delineated by long-wavelength gravity anomalies. A review of previously published seismic reflection profiles shows that these basins and arches formed as grabens and horsts during the Jurassic opening of the Gulf of Mexico. The Tampa Basin, which formed as a half-graben, extends further eastward than previously mapped and is bounded on the east by the Jay Fault zone. Similarly, the South Florida Basin

region is also bounded by the Jay Fault zone, but it probably consists of two or three separate northwest-trending basins.

The northwest trend of these basins is perpendicular to the trend of the other basins underlying the Floridan Plateau, suggesting the possibility of two stages of extension during the Jurassic. During the first stage, it is proposed that a northeast-southwest oriented extensional stress regime existed during the rotation of the Yucatan block out of the northern Gulf of Mexico. This resulted in the formation of northwest-trending basins along the western edge of the Floridan Plateau block. Subsequently, the stress field shifted to a northwest-southeast oriented extensional regime as North America separated from South America. This proposed shift would have caused southeastward extension along the southwestern half of the Floridan Plateau, sinistral and normal movement along the Jay Fault zone, the formation of the northeast-oriented Apalachicola and Tampa basins, and the translocation of the northwest oriented basins into the south Florida region.

The sedimentary accumulations overlying the Floridan Plateau basement show no indication of displacement since the Early to Middle Cretaceous, suggesting an extended period of tectonic quiescence. This quiescience is manifested in the unusually low level of seismic activity in region surrounding the Floridan Plateau. In contrast, other regions of the southeastern United States are relatively active. The primary reason for this nonuniform distribution of seismicity is probably the nonuniform distribution of appropriately oriented mid-crustal zones of weakness. The other possible reason is variability in the propensity for fault slippage

resulting from variations in hydrostatic pore pressures or frictional coefficients.

Seismic attenuation on the Floridan Plateau appears to be equivalent to that in other parts of the southeastern Coastal Plain. The estimated absorption coefficients were slightly higher than expected values for the central United States, but less than typical values in the western United States.

The probability of earthquake damage in Florida, either from local or distant events, is extremely low. The greatest hazard exists in the northwest corner of the state, where the annual probability of exceeding 0.2 g (MM intensity VIII) is only 8.0×10^{-5}.

APPENDIX
SEISMIC HAZARD PROBABILITIES FOR SITES IN FLORIDA

```
Peninsular Florida Seismic Hazard
 isw=0: new run--no previous results included
 extreme probability  0.990
   for exposure times (years)     1   50  100
 scale factor for ground motion "box" levels=    1.00
 coordinates input in decimal degrees
    coordinates are printed in decimal degrees
 variability in attenuation, sigma=  0.50
 grid oriented parallel to great circle thru (  87.00, 28.00),(  80.00, 28.00)
 corners of gridded area-upper left=  87.00,  31.15
                        lower right=  80.00,  25.00
 longitude increment= 0.5982 (decimal degrees)
 latitude increment = 0.5982 (decimal degrees)
 gridded region contains  11 rows,   11 cols including border    0 rows and cols
 for this run begin at row   1 end row  11, begin col   7 end col  11
 new coordinates (km) gridded area
      upper left=   677.85    -9.60; lower right=   350.50  -333.81
 sites are also located on   0 line(s)
 attenuation function Fla-Region
                              magnitude
   dist(km)     6.70      5.50      4.00
      80.00   0.15000   0.03450   0.00700
     130.00   0.05000   0.01640   0.00150
     240.00   0.03000   0.00480   0.00026
     360.00   0.01500   0.00164   0.00003
     580.00   0.00700   0.00030   0.00001

yrnoc=     1. iprint=-1 for area Char
     82.300    33.100    81.300    34.300
     81.000    32.100    79.700    33.500
 nr of levels of seismicity =  3
 Char beta= -1.0217
 earthquake rate / year
 occurrences=  0.000500  0.000300  0.000100
  magnitudes=       6.50      7.00      7.40
 Char area=   30369. sq km, rate/sq km= 0.16464E-07 for mags  6.25- 6.75

yrnoc=     1. iprint=-1 for area Pied
     80.300    37.500    77.000    37.500
     82.000    36.000    77.000    36.000
     87.000    32.000    79.700    32.000
 nr of levels of seismicity =  3
 Pied beta= -1.8388
 earthquake rate / year
 occurrences=  0.012500  0.007200  0.005000
  magnitudes=       5.50      5.80      6.00
 Pied area=  316141. sq km, rate/sq km= 0.39539E-07 for mags  5.35- 5.65

yrnoc=     1. iprint=-1 for area SApp
     82.800    37.500    80.300    37.500
     88.500    32.000    87.000    32.000
 nr of levels of seismicity =  3
 SApp beta= -2.0205
 earthquake rate / year
 occurrences=  0.002200  0.001200  0.000800
  magnitudes=       6.50      6.80      7.00
 SApp area=  111353. sq km, rate/sq km= 0.19757E-07 for mags  6.35- 6.65

yrnoc=     1. iprint=-1 for area NMad
     87.400    38.000    86.000    38.000
     90.300    35.300    88.000    35.300
 nr of levels of seismicity =  3
 NMad beta= -1.9330
 earthquake rate / year
 occurrences=  0.001300  0.000600  0.000200
  magnitudes=       7.40      7.80      8.30
 NMad area=   50440. sq km, rate/sq km= 0.25773E-07 for mags  7.20- 7.60

yrnoc=     1. iprint=-1 for area Caym
     86.700    18.500    77.000    20.700
     86.700    17.000    77.000    17.000
 nr of levels of seismicity =  4
 Caym beta= -2.1466
 earthquake rate / year
 occurrences=  0.011700  0.004000  0.001400  0.000500
  magnitudes=       7.00      7.50      8.00      8.50
 Caym area=  301315. sq km, rate/sq km= 0.38830E-07 for mags  6.75- 7.25

yrnoc=     1. iprint= 2 for area Flor
     90.000    32.000    77.000    32.000
     90.000    22.000    77.000    22.000
     86.000    18.700    77.000    20.700
 nr of levels of seismicity =  4
 Flor beta= -1.2681
 earthquake rate / year
 occurrences=  0.064600  0.038900  0.023400  0.014000
  magnitudes=       3.80      4.20      4.60      5.00
 Flor area= 1760366. sq km, rate/sq km= 0.36697E-07 for mags  3.60- 4.00
```

Peninsular Florida Seismic Hazard
site at long 82.812, lat 31.191
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18844	0.00195	97.4	511.6	0.02	0.18774	0.00265	71.7	376.8
0.04	0.00152	0.00043	439.4	2308.0	0.04	0.00187	0.00078	243.8	1280.6
0.06	0.00031	0.00013	1503.6	7897.0	0.06	0.00048	0.00030	629.6	3306.6
0.08	0.00009	0.00004	4615.1	24239.4	0.08	0.00016	0.00014	1381.3	7254.9
0.10	0.00004	0.00000	99999.9	99999.9	0.10	0.00007	0.00007	2742.2	14402.6
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00003	0.00004	5103.0	26801.8
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00002	0.00002	9075.4	47665.7
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00001	15591.1	81887.2
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00001	26036.2	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	42475.6	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	67910.6	99999.9
0.24	0.00000	0.00000	99999.9	99999.9	0.24	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability — variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years — 0.000 for 1 years
0.990 ext prob = 0.052 for 50 years — 0.070 for 50 years
0.990 ext prob = 0.064 for 100 years — 0.089 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00 0.00

Peninsular Florida Seismic Hazard
site at long 82.113, lat 31.186
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18853	0.00187	101.8	534.9	0.02	0.18782	0.00257	73.9	388.4
0.04	0.00138	0.00049	390.7	2052.1	0.04	0.00179	0.00079	241.6	1268.7
0.06	0.00033	0.00015	1242.5	6525.9	0.06	0.00047	0.00032	591.4	3106.4
0.08	0.00009	0.00006	3226.0	16943.4	0.08	0.00017	0.00015	1239.9	6512.0
0.10	0.00006	0.00000	99999.9	99999.9	0.10	0.00007	0.00008	2377.2	12485.5
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00004	0.00004	4308.3	22628.1
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00002	0.00003	7505.8	39421.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00002	12683.5	66615.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00001	0.00001	20896.5	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00001	33704.7	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	53361.8	99999.9
0.24	0.00000	0.00000	99999.9	99999.9	0.24	0.00000	0.00000	83099.7	99999.9
0.26	0.00000	0.00000	99999.9	99999.9	0.26	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability — veriability in etten, sigma=0.50
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years — 0.000 for 1 years
0.990 ext prob = 0.055 for 50 years — 0.073 for 50 years
0.990 ext prob = 0.069 for 100 years — 0.093 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00 0.00

Peninsular Florida Seismic Hazard
site at long 81.415, lat 31.178
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18862	0.00179	106.4	558.6	0.02	0.18795	0.00246	77.3	405.8
0.04	0.00125	0.00054	355.2	1865.5	0.04	0.00167	0.00079	240.5	1262.9
0.06	0.00036	0.00018	1072.6	5632.9	0.06	0.00045	0.00034	562.1	2951.7
0.08	0.00011	0.00007	2665.9	14000.8	0.08	0.00017	0.00017	1138.4	5978.4
0.10	0.00007	0.00000	99999.9	99999.9	0.10	0.00008	0.00009	2130.6	11189.6
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00004	0.00005	3794.4	19927.3
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00002	0.00003	6521.2	34247.6
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00002	10896.7	57226.4
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00001	0.00001	17778.8	93369.8
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00001	28424.0	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	44630.1	99999.9
0.24	0.00000	0.00000	99999.9	99999.9	0.24	0.00000	0.00000	68950.2	99999.9
0.26	0.00000	0.00000	99999.9	99999.9	0.26	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19041				total yearly events	0.19041			

zero attenuation variability — variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years — 0.000 for 1 years
0.990 ext prob = 0.058 for 50 years — 0.075 for 50 years
0.990 ext prob = 0.072 for 100 years — 0.096 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00 0.00

```
Peninsular Florida Seismic Hazard
 site at long   80.717, lat   31.166
 shortest dist to fault= 9999.999 km
         zero attenuation variability                     variability in atten, sigma= 0.50
    g.m.   occ/yr    exc/yr  r(events) r(yrs)      g.m.   occ/yr    exc/yr  r(events) r(yrs)
     0.02  0.18867  0.00174    109.7    576.2       0.02  0.18815  0.00226     84.3    442.7
     0.04  0.00119  0.00054    352.2   1849.7       0.04  0.00149  0.00077    248.9   1307.2
     0.06  0.00037  0.00018   1088.0   5713.9       0.06  0.00043  0.00033    570.1   2993.9
     0.08  0.00010  0.00007   2649.4  13914.7       0.08  0.00017  0.00017   1145.7   6017.3
     0.10  0.00007  0.00000  99999.9  99999.9       0.10  0.00008  0.00009   2137.7  11227.0
     0.12  0.00000  0.00000  99999.9  99999.9       0.12  0.00004  0.00005   3800.8  19961.8
     0.14  0.00000  0.00000  99999.9  99999.9       0.14  0.00002  0.00003   6524.6  34267.1
     0.16  0.00000  0.00000  99999.9  99999.9       0.16  0.00001  0.00002  10890.5  57196.2
     0.18  0.00000  0.00000  99999.9  99999.9       0.18  0.00001  0.00001  17748.6  93214.9
     0.20  0.00000  0.00000  99999.9  99999.9       0.20  0.00000  0.00001  28339.5  99999.9
     0.22  0.00000  0.00000  99999.9  99999.9       0.22  0.00000  0.00000  44434.3  99999.9
     0.24  0.00000  0.00000  99999.9  99999.9       0.24  0.00000  0.00000  68540.0  99999.9
     0.26  0.00000  0.00000  99999.9  99999.9       0.26  0.00000  0.00000  99999.9  99999.9
   total yearly events    0.19041               total yearly events    0.19041

         zero attenuation variability                     variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
     0.990 ext prob =  0.000 for      1 years                      0.000 for    1 years
     0.990 ext prob =  0.058 for     50 years                      0.075 for   50 years
     0.990 ext prob =  0.072 for    100 years                      0.096 for  100 years
   ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00          0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   80.020, lat   31.150
 shortest dist to fault= 9999.999 km
         zero attenuation variability                     variability in atten, sigma= 0.50
    g.m.   occ/yr    exc/yr  r(events) r(yrs)      g.m.   occ/yr    exc/yr  r(events) r(yrs)
     0.02  0.18877  0.00163    116.6    612.3       0.02  0.18840  0.00200     95.1    499.6
     0.04  0.00114  0.00049    387.5   2035.0       0.04  0.00130  0.00070    273.2   1434.6
     0.06  0.00034  0.00015   1255.0   6591.1       0.06  0.00039  0.00030    629.7   3307.1
     0.08  0.00009  0.00006   3339.6  17539.7       0.08  0.00015  0.00015   1284.0   6743.4
     0.10  0.00006  0.00000  99999.9  99999.9       0.10  0.00007  0.00008   2431.9  12772.6
     0.12  0.00000  0.00000  99999.9  99999.9       0.12  0.00003  0.00004   4385.5  23032.8
     0.14  0.00000  0.00000  99999.9  99999.9       0.14  0.00002  0.00002   7627.0  40057.2
     0.16  0.00000  0.00000  99999.9  99999.9       0.16  0.00001  0.00001  12885.3  67674.2
     0.18  0.00000  0.00000  99999.9  99999.9       0.18  0.00001  0.00001  21240.7  99999.9
     0.20  0.00000  0.00000  99999.9  99999.9       0.20  0.00000  0.00001  34286.6  99999.9
     0.22  0.00000  0.00000  99999.9  99999.9       0.22  0.00000  0.00000  54327.5  99999.9
     0.24  0.00000  0.00000  99999.9  99999.9       0.24  0.00000  0.00000  84668.5  99999.9
     0.26  0.00000  0.00000  99999.9  99999.9       0.26  0.00000  0.00000  99999.9  99999.9
   total yearly events    0.19040               total yearly events    0.19040

         zero attenuation variability                     variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
     0.990 ext prob =  0.000 for      1 years                      0.000 for    1 years
     0.990 ext prob =  0.055 for     50 years                      0.071 for   50 years
     0.990 ext prob =  0.068 for    100 years                      0.092 for  100 years
   ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00          0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   82.816, lat   30.593
 shortest dist to fault= 9999.999 km
         zero attenuation variability                     variability in atten, sigma= 0.50
    g.m.   occ/yr    exc/yr  r(events) r(yrs)      g.m.   occ/yr    exc/yr  r(events) r(yrs)
     0.02  0.18910  0.00130    146.7    770.6       0.02  0.18866  0.00174    109.2    573.7
     0.04  0.00096  0.00034    567.3   2979.7       0.04  0.00121  0.00053    356.1   1870.2
     0.06  0.00024  0.00010   2004.0  10524.9       0.06  0.00032  0.00021    891.4   4681.8
     0.08  0.00008  0.00001  16472.1  86512.3       0.08  0.00012  0.00010   1951.1  10247.0
     0.10  0.00001  0.00000  99999.9  99999.9       0.10  0.00005  0.00005   3940.5  20695.8
     0.12  0.00000  0.00000  99999.9  99999.9       0.12  0.00002  0.00003   7536.9  39584.0
     0.14  0.00000  0.00000  99999.9  99999.9       0.14  0.00001  0.00001  13836.8  72671.8
     0.16  0.00000  0.00000  99999.9  99999.9       0.16  0.00001  0.00001  24567.7  99999.9
     0.18  0.00000  0.00000  99999.9  99999.9       0.18  0.00000  0.00000  42383.4  99999.9
     0.20  0.00000  0.00000  99999.9  99999.9       0.20  0.00000  0.00000  71343.2  99999.9
     0.22  0.00000  0.00000  99999.9  99999.9       0.22  0.00000  0.00000  99999.9  99999.9
   total yearly events    0.19040               total yearly events    0.19040

         zero attenuation variability                     variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
     0.990 ext prob =  0.000 for      1 years                      0.000 for    1 years
     0.990 ext prob =  0.048 for     50 years                      0.062 for   50 years
     0.990 ext prob =  0.059 for    100 years                      0.079 for  100 years
   ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00          0.00
```

Peninsular Florida Seismic Hazard
site at long 82.121, lat 30.588
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18918	0.00122	156.0	819.6	0.02	0.18872	0.00168	113.3	594.8
0.04	0.00085	0.00037	509.2	2674.5	0.04	0.00114	0.00054	354.8	1863.5
0.06	0.00026	0.00011	1730.1	9086.5	0.06	0.00031	0.00023	844.6	4436.1
0.08	0.00009	0.00002	8138.2	42743.1	0.08	0.00012	0.00011	1771.6	9304.9
0.10	0.00002	0.00000	99999.9	99999.9	0.10	0.00005	0.00006	3457.8	18160.8
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00003	0.00003	6427.1	33755.8
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00002	11508.9	60446.2
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00001	19983.7	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00001	33782.4	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	55808.4	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	90327.2	99999.9
0.24	0.00000	0.00000	99999.9	99999.9	0.24	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability		variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob = 0.000 for 1 years		0.000 for 1 years
0.990 ext prob = 0.050 for 50 years		0.063 for 50 years
0.990 ext prob = 0.061 for 100 years		0.082 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val	= 0.00	0.00

Peninsular Florida Seismic Hazard
site at long 81.427, lat 30.580
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18920	0.00122	156.5	821.8	0.02	0.18883	0.00158	120.2	631.0
0.04	0.00082	0.00039	483.1	2537.2	0.04	0.00105	0.00054	354.5	1861.8
0.06	0.00027	0.00012	1594.5	8373.9	0.06	0.00030	0.00023	816.6	4288.8
0.08	0.00009	0.00003	6477.6	34018.3	0.08	0.00012	0.00011	1678.6	8815.6
0.10	0.00003	0.00000	99999.9	99999.9	0.10	0.00005	0.00006	3228.9	16957.1
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00003	0.00003	5932.7	31156.6
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00002	10520.8	55252.1
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00001	18114.6	95132.5
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00001	30397.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	49885.9	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	80257.8	99999.9
0.24	0.00000	0.00000	99999.9	99999.9	0.24	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19041			total yearly events		0.19041		

zero attenuation variability		variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob = 0.000 for 1 years		0.000 for 1 years
0.990 ext prob = 0.051 for 50 years		0.064 for 50 years
0.990 ext prob = 0.062 for 100 years		0.084 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val	= 0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.733, lat 30.568
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18920	0.00121	157.7	828.2	0.02	0.18893	0.00148	128.9	676.9
0.04	0.00082	0.00039	489.7	2571.8	0.04	0.00095	0.00052	364.0	1911.5
0.06	0.00027	0.00012	1575.7	8275.7	0.06	0.00029	0.00023	827.9	4348.1
0.08	0.00009	0.00003	6731.4	35353.3	0.08	0.00012	0.00011	1694.4	8899.2
0.10	0.00003	0.00000	99999.9	99999.9	0.10	0.00005	0.00006	3253.8	17088.7
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00003	0.00003	5974.9	31380.2
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00002	10595.6	55648.2
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00001	18249.3	95845.2
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00001	30642.4	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	50322.8	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	81023.2	99999.9
0.24	0.00000	0.00000	99999.9	99999.9	0.24	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability		variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob = 0.000 for 1 years		0.000 for 1 years
0.990 ext prob = 0.051 for 50 years		0.064 for 50 years
0.990 ext prob = 0.063 for 100 years		0.083 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val	= 0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.039, lat 30.553
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18923	0.00117	162.5	853.4	0.02	0.18903	0.00137	138.6	727.9
0.04	0.00081	0.00036	522.7	2745.1	0.04	0.00088	0.00050	384.6	2020.1
0.06	0.00025	0.00011	1725.1	9060.5	0.06	0.00028	0.00022	881.9	4631.8
0.08	0.00009	0.00002	9113.1	47862.4	0.08	0.00011	0.00010	1827.5	9598.0
0.10	0.00002	0.00000	99999.9	99999.9	0.10	0.00005	0.00005	3552.9	18659.8
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00003	6599.9	34663.0
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00002	11829.0	62126.2
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00001	20572.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00001	34854.7	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	57713.5	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	93631.5	99999.9
0.24	0.00000	0.00000	99999.9	99999.9	0.24	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.050 for 50 years	0.062 for 50 years
0.990 ext prob = 0.061 for 100 years	0.081 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.819, lat 29.995
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18929	0.00111	170.9	897.7	0.02	0.18900	0.00140	136.4	716.3
0.04	0.00081	0.00030	629.9	3308.5	0.04	0.00094	0.00045	418.9	2200.3
0.06	0.00024	0.00006	3076.7	16159.3	0.06	0.00027	0.00018	1053.9	5535.1
0.08	0.00006	0.00001	33173.9	99999.9	0.08	0.00010	0.00008	2364.8	12420.5
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	4923.0	25856.3
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	9702.1	50956.6
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	18311.6	96174.6
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	33336.0	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	58808.1	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.045 for 50 years	0.058 for 50 years
0.990 ext prob = 0.054 for 100 years	0.075 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.129, lat 29.990
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18930	0.00111	171.9	902.6	0.02	0.18909	0.00132	144.5	759.1
0.04	0.00080	0.00031	620.7	3260.2	0.04	0.00087	0.00045	423.6	2224.9
0.06	0.00023	0.00007	2623.4	13778.2	0.06	0.00027	0.00018	1038.0	5451.8
0.08	0.00007	0.00001	32754.0	99999.9	0.08	0.00010	0.00008	2286.1	12006.6
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	4690.4	24634.1
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	9138.9	47997.6
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	17094.2	89778.8
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	30899.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	54212.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	92697.3	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.046 for 50 years	0.058 for 50 years
0.990 ext prob = 0.055 for 100 years	0.075 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Peninsular Florida Seismic Hazard
site at long 81.439, lat 29.982
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18929	0.00111	170.9	897.5
0.04	0.00080	0.00031	605.2	3178.4
0.06	0.00024	0.00008	2453.5	12885.8
0.08	0.00007	0.00001	25568.5	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18916	0.00125	152.6	801.7
0.04	0.00080	0.00045	425.3	2233.9
0.06	0.00026	0.00019	1020.2	5358.0
0.08	0.00010	0.00009	2218.5	11651.5
0.10	0.00004	0.00004	4508.9	23680.7
0.12	0.00002	0.00002	8716.3	45778.3
0.14	0.00001	0.00001	16190.9	85035.0
0.16	0.00001	0.00001	29083.2	99999.9
0.18	0.00000	0.00000	50736.4	99999.9
0.20	0.00000	0.00000	86294.0	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability		variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.046 for 50 years	0.058 for 50 years
0.990 ext prob =	0.056 for 100 years	0.076 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.749, lat 29.970
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18929	0.00111	171.2	899.2
0.04	0.00080	0.00031	606.4	3184.6
0.06	0.00024	0.00008	2489.2	13073.6
0.08	0.00007	0.00001	25571.0	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18920	0.00120	158.4	832.0
0.04	0.00076	0.00044	430.6	2261.4
0.06	0.00026	0.00019	1026.8	5392.7
0.08	0.00010	0.00009	2230.9	11716.6
0.10	0.00004	0.00004	4535.5	23820.8
0.12	0.00002	0.00002	8772.8	46075.1
0.14	0.00001	0.00001	16304.4	85631.9
0.16	0.00001	0.00001	29299.8	99999.9
0.18	0.00000	0.00000	51134.1	99999.9
0.20	0.00000	0.00000	86995.6	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability		variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.046 for 50 years	0.058 for 50 years
0.990 ext prob =	0.056 for 100 years	0.076 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.059, lat 29.955
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18930	0.00110	172.9	907.9
0.04	0.00080	0.00031	621.6	3264.4
0.06	0.00024	0.00007	2726.3	14318.7
0.08	0.00006	0.00001	32186.5	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18922	0.00118	161.0	845.8
0.04	0.00075	0.00043	438.6	2303.6
0.06	0.00025	0.00018	1055.2	5542.0
0.08	0.00010	0.00008	2315.5	12161.3
0.10	0.00004	0.00004	4752.2	24959.2
0.12	0.00002	0.00002	9270.9	48691.5
0.14	0.00001	0.00001	17363.1	91192.2
0.16	0.00000	0.00001	31418.7	99999.9
0.18	0.00000	0.00000	55176.1	99999.9
0.20	0.00000	0.00000	94410.5	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability		variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.046 for 50 years	0.058 for 50 years
0.990 ext prob =	0.055 for 100 years	0.075 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.823, lat 29.397
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18943	0.00097	196.5	1032.0	0.02	0.18921	0.00119	159.6	838.3
0.04	0.00067	0.00030	629.5	3306.2	0.04	0.00078	0.00041	463.9	2436.6
0.06	0.00025	0.00005	3819.6	20060.7	0.06	0.00024	0.00017	1138.8	5980.9
0.08	0.00004	0.00001	33174.1	99999.9	0.08	0.00009	0.00008	2537.5	13327.0
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	5292.5	27796.5
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	10487.9	55083.6
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	19922.7	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	36495.3	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	64735.1	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.045 for 50 years	0.056 for 50 years
0.990 ext prob = 0.052 for 100 years	0.073 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.137, lat 29.392
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18940	0.00100	189.5	995.4	0.02	0.18926	0.00114	166.3	873.6
0.04	0.00070	0.00030	627.8	3297.1	0.04	0.00073	0.00041	462.9	2431.0
0.06	0.00025	0.00005	3748.8	19688.8	0.06	0.00024	0.00017	1127.2	5920.1
0.08	0.00005	0.00001	33174.6	99999.9	0.08	0.00009	0.00008	2510.5	13185.2
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	5238.5	27512.5
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	10384.0	54536.9
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	19726.6	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	36133.2	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	64092.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.045 for 50 years	0.056 for 50 years
0.990 ext prob = 0.052 for 100 years	0.073 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Peninsular Florida Seismic Hazard
site at long 81.451, lat 29.383
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18938	0.00103	185.7	975.2	0.02	0.18929	0.00111	170.9	897.4
0.04	0.00072	0.00030	628.6	3301.6	0.04	0.00070	0.00041	462.5	2429.3
0.06	0.00025	0.00005	3609.4	18956.9	0.06	0.00024	0.00017	1119.8	5881.3
0.08	0.00005	0.00001	33174.4	99999.9	0.08	0.00009	0.00008	2489.1	13072.7
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	5185.6	27234.9
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	10263.5	53904.4
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	19469.6	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	35615.7	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	63109.1	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.045 for 50 years	0.056 for 50 years
0.990 ext prob = 0.053 for 100 years	0.073 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.764, lat 29.372
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18937	0.00103	184.9	971.1	0.02	0.18929	0.00112	170.7	896.7
0.04	0.00073	0.00030	628.9	3303.1	0.04	0.00070	0.00041	461.7	2425.0
0.06	0.00025	0.00005	3612.5	18973.3	0.06	0.00024	0.00017	1118.5	5874.5
0.08	0.00005	0.00001	33174.3	99999.9	0.08	0.00009	0.00008	2487.6	13065.1
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	5184.6	27229.9
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	10264.2	53908.2
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	19474.1	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	35627.7	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	63135.0	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.045 for 50 years	0.056 for 50 years
0.990 ext prob =	0.053 for 100 years	0.073 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.078, lat 29.357
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18939	0.00101	188.5	990.0	0.02	0.18930	0.00110	172.5	905.9
0.04	0.00071	0.00030	629.1	3304.2	0.04	0.00070	0.00041	466.8	2451.5
0.06	0.00025	0.00005	3744.0	19663.7	0.06	0.00024	0.00017	1129.9	5934.1
0.08	0.00005	0.00001	33174.2	99999.9	0.08	0.00009	0.00008	2513.0	13198.7
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	5242.0	27531.2
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	10389.6	54567.1
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	19735.2	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	36144.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	64110.6	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.045 for 50 years	0.056 for 50 years
0.990 ext prob =	0.052 for 100 years	0.073 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.827, lat 28.799
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18956	0.00084	226.1	1187.7	0.02	0.18938	0.00102	186.0	977.1
0.04	0.00056	0.00028	671.8	3528.5	0.04	0.00066	0.00037	521.0	2736.5
0.06	0.00023	0.00005	3819.6	20060.7	0.06	0.00021	0.00015	1246.6	6547.2
0.08	0.00004	0.00001	33174.1	99999.9	0.08	0.00008	0.00007	2729.1	14333.6
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00003	5622.3	29529.1
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	11041.4	57990.4
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	20828.2	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	37940.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	66993.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.044 for 50 years	0.054 for 50 years
0.990 ext prob =	0.052 for 100 years	0.071 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

```
Peninsular Florida Seismic Hazard
 site at long   82.144, lat   28.794
 shortest dist to fault= 9999.999 km
         zero attenuation variability                     variability in atten, sigma= 0.50
    g.m.    occ/yr    exc/yr  r(events) r(yrs)      g.m.    occ/yr    exc/yr  r(events) r(yrs)
     0.02  0.18952  0.00088    217.0  1139.5        0.02  0.18937  0.00103    185.0   971.6
     0.04  0.00058  0.00029    646.4  3395.2        0.04  0.00065  0.00038    505.9  2656.8
     0.06  0.00024  0.00005   3819.6 20060.7        0.06  0.00022  0.00016   1206.1  6334.5
     0.08  0.00004  0.00001  33174.1 99999.9        0.08  0.00009  0.00007   2644.7 13890.4
     0.10  0.00001  0.00000  99999.9 99999.9        0.10  0.00004  0.00003   5463.4 28694.4
     0.12  0.00000  0.00000  99999.9 99999.9        0.12  0.00002  0.00002  10759.5 56510.2
     0.14  0.00000  0.00000  99999.9 99999.9        0.14  0.00001  0.00001  20349.6 99999.9
     0.16  0.00000  0.00000  99999.9 99999.9        0.16  0.00000  0.00001  37155.8 99999.9
     0.18  0.00000  0.00000  99999.9 99999.9        0.18  0.00000  0.00000  65745.9 99999.9
     0.20  0.00000  0.00000  99999.9 99999.9        0.20  0.00000  0.00000  99999.9 99999.9
   total yearly events     0.19040               total yearly events     0.19040

         zero attenuation variability                     variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
     0.990 ext prob =  0.000 for     1 years                       0.000 for    1 years
     0.990 ext prob =  0.044 for    50 years                       0.054 for   50 years
     0.990 ext prob =  0.052 for   100 years                       0.072 for  100 years
   ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00           0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   81.462, lat   28.785
 shortest dist to fault= 9999.999 km
         zero attenuation variability                     variability in atten, sigma= 0.50
    g.m.    occ/yr    exc/yr  r(events) r(yrs)      g.m.    occ/yr    exc/yr  r(events) r(yrs)
     0.02  0.18951  0.00089    213.5  1121.1        0.02  0.18936  0.00104    182.8   960.3
     0.04  0.00059  0.00030    639.7  3359.8        0.04  0.00066  0.00038    499.4  2623.2
     0.06  0.00025  0.00005   3819.6 20060.7        0.06  0.00022  0.00016   1192.4  6262.4
     0.08  0.00004  0.00001  33174.1 99999.9        0.08  0.00009  0.00007   2618.5 13752.9
     0.10  0.00001  0.00000  99999.9 99999.9        0.10  0.00004  0.00004   5416.2 28446.6
     0.12  0.00000  0.00000  99999.9 99999.9        0.12  0.00002  0.00002  10677.9 56081.7
     0.14  0.00000  0.00000  99999.9 99999.9        0.14  0.00001  0.00001  20213.2 99999.9
     0.16  0.00000  0.00000  99999.9 99999.9        0.16  0.00000  0.00001  36934.4 99999.9
     0.18  0.00000  0.00000  99999.9 99999.9        0.18  0.00000  0.00000  65396.0 99999.9
     0.20  0.00000  0.00000  99999.9 99999.9        0.20  0.00000  0.00000  99999.9 99999.9
   total yearly events     0.19040               total yearly events     0.19040

         zero attenuation variability                     variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
     0.990 ext prob =  0.000 for     1 years                       0.000 for    1 years
     0.990 ext prob =  0.044 for    50 years                       0.055 for   50 years
     0.990 ext prob =  0.052 for   100 years                       0.072 for  100 years
   ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00           0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   80.780, lat   28.774
 shortest dist to fault= 9999.999 km
         zero attenuation variability                     variability in atten, sigma= 0.50
    g.m.    occ/yr    exc/yr  r(events) r(yrs)      g.m.    occ/yr    exc/yr  r(events) r(yrs)
     0.02  0.18951  0.00089    214.2  1125.0        0.02  0.18936  0.00104    183.1   961.9
     0.04  0.00059  0.00030    640.4  3363.3        0.04  0.00066  0.00038    500.5  2628.5
     0.06  0.00025  0.00005   3819.6 20060.7        0.06  0.00022  0.00016   1194.4  6273.2
     0.08  0.00004  0.00001  33174.1 99999.9        0.08  0.00009  0.00007   2622.1 13771.8
     0.10  0.00001  0.00000  99999.9 99999.9        0.10  0.00004  0.00004   5422.3 28478.4
     0.12  0.00000  0.00000  99999.9 99999.9        0.12  0.00002  0.00002  10687.8 56133.6
     0.14  0.00000  0.00000  99999.9 99999.9        0.14  0.00001  0.00001  20229.0 99999.9
     0.16  0.00000  0.00000  99999.9 99999.9        0.16  0.00000  0.00001  36959.3 99999.9
     0.18  0.00000  0.00000  99999.9 99999.9        0.18  0.00000  0.00000  65434.4 99999.9
     0.20  0.00000  0.00000  99999.9 99999.9        0.20  0.00000  0.00000  99999.9 99999.9
   total yearly events     0.19040               total yearly events     0.19040

         zero attenuation variability                     variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
     0.990 ext prob =  0.000 for     1 years                       0.000 for    1 years
     0.990 ext prob =  0.044 for    50 years                       0.055 for   50 years
     0.990 ext prob =  0.052 for   100 years                       0.072 for  100 years
   ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00           0.00
```

Peninsular Florida Seismic Hazard
site at long 80.098, lat 28.759
shortest dist to fault= 9999.999 km

	zero attenuation variability				variability in atten, sigma= 0.50			
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18953	0.00087	218.8	1149.4	0.18937	0.00103	185.5	974.3
0.04	0.00058	0.00029	647.1	3398.4	0.00065	0.00037	507.9	2667.7
0.06	0.00024	0.00005	3819.6	20060.7	0.00022	0.00016	1210.0	6355.3
0.08	0.00004	0.00001	33174.1	99999.9	0.00009	0.00007	2651.0	13923.5
0.10	0.00001	0.00000	99999.9	99999.9	0.00004	0.00003	5473.0	28744.9
0.12	0.00000	0.00000	99999.9	99999.9	0.00002	0.00002	10774.0	56586.0
0.14	0.00000	0.00000	99999.9	99999.9	0.00001	0.00001	20371.1	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	37187.8	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	65792.4	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				0.19040			

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.044 for 50 years	0.054 for 50 years
0.990 ext prob =	0.052 for 100 years	0.071 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.831, lat 28.200
shortest dist to fault= 9999.999 km

	zero attenuation variability				variability in atten, sigma= 0.50			
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18965	0.00075	253.1	1329.1	0.18951	0.00089	212.8	1117.4
0.04	0.00051	0.00025	773.1	4060.4	0.00057	0.00032	590.6	3102.0
0.06	0.00020	0.00005	3819.6	20060.7	0.00019	0.00014	1402.6	7366.8
0.08	0.00004	0.00001	33174.1	99999.9	0.00007	0.00006	3042.5	15979.4
0.10	0.00001	0.00000	99999.9	99999.9	0.00003	0.00003	6205.1	32589.8
0.12	0.00000	0.00000	99999.9	99999.9	0.00001	0.00002	12066.6	63374.8
0.14	0.00000	0.00000	99999.9	99999.9	0.00001	0.00001	22556.1	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	40753.0	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	71441.4	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				0.19040			

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.043 for 50 years	0.051 for 50 years
0.990 ext prob =	0.051 for 100 years	0.068 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.152, lat 28.195
shortest dist to fault= 9999.999 km

	zero attenuation variability				variability in atten, sigma= 0.50			
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18963	0.00077	248.4	1304.8	0.18948	0.00092	207.9	1092.1
0.04	0.00051	0.00026	746.5	3920.8	0.00059	0.00033	576.2	3026.1
0.06	0.00021	0.00005	3819.6	20060.7	0.00019	0.00014	1367.4	7181.7
0.08	0.00004	0.00001	33174.1	99999.9	0.00008	0.00006	2968.7	15591.7
0.10	0.00001	0.00000	99999.9	99999.9	0.00003	0.00003	6065.1	31854.3
0.12	0.00000	0.00000	99999.9	99999.9	0.00002	0.00002	11818.0	62069.2
0.14	0.00000	0.00000	99999.9	99999.9	0.00001	0.00001	22135.5	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	40067.8	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	70357.7	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				0.19040			

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.043 for 50 years	0.052 for 50 years
0.990 ext prob =	0.051 for 100 years	0.068 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

```
Peninsular Florida Seismic Hazard
 site at long   81.473, lat   28.187
 shortest dist to fault= 9999.999 km
        zero attenuation variability                      variability in atten, sigma= 0.50
   g.m.    occ/yr     exc/yr  r(events) r(yrs)       g.m.    occ/yr     exc/yr  r(events) r(yrs)
    0.02  0.18962  0.00078    245.4   1288.7         0.02  0.18947  0.00093    205.2   1077.9
    0.04  0.00052  0.00026    732.7   3848.3         0.04  0.00059  0.00034    567.9   2982.8
    0.06  0.00021  0.00005   3819.6  20060.7         0.06  0.00019  0.00014   1347.8   7078.6
    0.08  0.00004  0.00001  33174.1  99999.9         0.08  0.00008  0.00007   2928.2  15379.3
    0.10  0.00001  0.00000  99999.9  99999.9         0.10  0.00003  0.00003   5989.0  31454.7
    0.12  0.00000  0.00000  99999.9  99999.9         0.12  0.00002  0.00002  11683.4  61362.5
    0.14  0.00000  0.00000  99999.9  99999.9         0.14  0.00001  0.00001  21908.2  99999.9
    0.16  0.00000  0.00000  99999.9  99999.9         0.16  0.00000  0.00000  39697.6  99999.9
    0.18  0.00000  0.00000  99999.9  99999.9         0.18  0.00000  0.00000  69772.3  99999.9
    0.20  0.00000  0.00000  99999.9  99999.9         0.20  0.00000  0.00000  99999.9  99999.9
  total yearly events    0.19040                   total yearly events    0.19040

        zero attenuation variability                      variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext orob =  0.000 for     1 years                          0.000 for     1 years   . .
    0.990 ext prob =  0.043 for    50 years                          0.052 for    50 years
    0.990 ext prob =  0.052 for   100 years                          0.069 for   100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00          0.00
```

```
Peninsular Florida Saismic Hazard
 site at long   80.795, lat   28.176
 shortest dist to fault= 9999.999 km
        zero attenuation variabilitv                      variability in atten, sigma= 0.50
   g.m.    occ/yr     exc/vr  r(events) r(yrs)       g.m.    occ/yr     exc/yr  r(events) r(yrs)
    0.02  0.18962  0.00078    245.4   1289.0         0.02  0.18947  0.00093    205.3   1078.2
    0.04  0.00052  0.00026    732.7   3848.3         0.04  0.00059  0.00034    568.0   2983.4
    0.06  0.00021  0.00005   3819.6  20060.7         0.06  0.00019  0.00014   1347.9   7079.3
    0.08  0.00004  0.00001  33174.1  99999.9         0.08  0.00008  0.00007   2928.4  15380.3
    0.10  0.00001  0.00000  99999.9  99999.9         0.10  0.00003  0.00003   5989.2  31456.0
    0.12  0.00000  0.00000  99999.9  99999.9         0.12  0.00002  0.00002  11683.8  61364.3
    0.14  0.00000  0.00000  99999.9  99999.9         0.14  0.00001  0.00001  21908.7  99999.9
    0.16  0.00000  0.00000  99999.9  99999.9         0.16  0.00000  0.00000  39698.2  99999.9
    0.18  0.00000  0.00000  99999.9  99999.9         0.18  0.00000  0.00000  69773.3  99999.9
    0.20  0.00000  0.00000  99999.9  99999.9         0.20  0.00000  0.00000  99999.9  99999.9
  total yearly events    0.19040                   total yearly avents    0.19040

        zero attenuation variability                      variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                          0.000 for     1 years
    0.990 ext prob =  0.043 for    50 years                          0.052 for    50 years
    0.990 ext prob =  0.052 for   100 years                          0.069 for   100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00          0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   80.117, lat   28.161
 shortest dist to fault= 9999.999 km
        zero attenuation variability                      variability in atten, sigma= 0.50
   g.m.    occ/yr     exc/yr  r(events) r(yrs)       g.m.    occ/yr     exc/yr  r(events) r(yrs)
    0.02  0.18963  0.00077    248.9   1307.1         0.02  0.18949  0.00091    208.6   1095.8
    0.04  0.00051  0.00025    750.3   3940.5         0.04  0.00058  0.00033    578.1   3036.2
    0.06  0.00020  0.00005   3819.6  20060.7         0.06  0.00019  0.00014   1372.1   7206.4
    0.08  0.00004  0.00001  33174.1  99999.9         0.08  0.00007  0.00006   2978.7  15644.3
    0.10  0.00001  0.00000  99999.9  99999.9         0.10  0.00003  0.00003   6084.3  31955.4
    0.12  0.00000  0.00000  99999.9  99999.9         0.12  0.00002  0.00002  11852.5  62250.5
    0.14  0.00000  0.00000  99999.9  99999.9         0.14  0.00001  0.00001  22194.4  99999.9
    0.16  0.00000  0.00000  99999.9  99999.9         0.16  0.00000  0.00000  40164.2  99999.9
    0.18  0.00000  0.00000  99999.9  99999.9         0.18  0.00000  0.00000  70511.0  99999.9
    0.20  0.00000  0.00000  99999.9  99999.9         0.20  0.00000  0.00000  99999.9  99999.9
  total yearly events    0.19040                   total yearly events    0.19040

        zero attenuation variability                      variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                          0.000 for     1 years
    0.990 ext prob =  0.043 for    50 years                          0.051 for    50 years
    0.990 ext prob =  0.051 for   100 years                          0.068 for   100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00          0.00
```

```
Peninsuler Florida Seismic Hazard
 site at long   82.834, lat   27.602
 shortest dist to fault= 9999.999 km
        zero attenuation variability                       variability in atten, sigma= 0.50
   g.m.   occ/yr    exc/yr  r(events) r(yrs)       g.m.   occ/yr    exc/yr  r(events) r(yrs)
    0.02  0.18968  0.00072    265.2   1392.9        0.02  0.18958  0.00082    231.9   1218.1
    0.04  0.00051  0.00021    898.6   4719.5        0.04  0.00053  0.00029    646.3   3394.2
    0.06  0.00016  0.00005   3819.6  20060.7        0.06  0.00017  0.00012   1545.0   8114.4
    0.08  0.00004  0.00001  33174.1  99999.9        0.08  0.00007  0.00006   3349.9  17594.2
    0.10  0.00001  0.00000  99999.9  99999.9        0.10  0.00003  0.00003   6795.6  35691.2
    0.12  0.00000  0.00000  99999.9  99999.9        0.12  0.00001  0.00001  13117.4  68894.1
    0.14  0.00000  0.00000  99999.9  99999.9        0.14  0.00001  0.00001  24330.0  99999.9
    0.16  0.00000  0.00000  99999.9  99999.9        0.16  0.00000  0.00000  43630.9  99999.9
    0.18  0.00000  0.00000  99999.9  99999.9        0.18  0.00000  0.00000  75971.9  99999.9
    0.20  0.00000  0.00000  99999.9  99999.9        0.20  0.00000  0.00000  99999.9  99999.9
  total yearly events    0.19040                  total yearly events    0.19040

        zero attenuation variability                       variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                      0.000 for    1 years
    0.990 ext prob =  0.041 for    50 years                      0.049 for   50 years
    0.990 ext prob =  0.050 for   100 years                      0.065 for  100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00            0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   82.160, lat   27.597
 shortest dist to fault= 9999.999 km
        zero attenuation variability                       variability in atten, sigma= 0.50
   g.m.   occ/yr    exc/yr  r(events) r(yrs)       g.m.   occ/yr    exc/yr  r(events) r(yrs)
    0.02  0.18968  0.00072    263.2   1382.6        0.02  0.18957  0.00083    228.7   1201.3
    0.04  0.00051  0.00022    876.4   4603.2        0.04  0.00053  0.00030    637.0   3345.4
    0.06  0.00017  0.00005   3819.6  20060.7        0.06  0.00017  0.00013   1521.0   7988.4
    0.08  0.00004  0.00001  33174.1  99999.9        0.08  0.00007  0.00006   3298.1  17322.0
    0.10  0.00001  0.00000  99999.9  99999.9        0.10  0.00003  0.00003   6696.5  35170.5
    0.12  0.00000  0.00000  99999.9  99999.9        0.12  0.00001  0.00001  12942.1  67973.1
    0.14  0.00000  0.00000  99999.9  99999.9        0.14  0.00001  0.00001  24035.9  99999.9
    0.16  0.00000  0.00000  99999.9  99999.9        0.16  0.00000  0.00000  43156.7  99999.9
    0.18  0.00000  0.00000  99999.9  99999.9        0.18  0.00000  0.00000  75229.6  99999.9
    0.20  0.00000  0.00000  99999.9  99999.9        0.20  0.00000  0.00000  99999.9  99999.9
  total yearly events    0.19040                  total yearly events    0.19040

        zero attenuation variability                       variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                      0.000 for    1 years
    0.990 ext prob =  0.041 for    50 years                      0.049 for   50 years
    0.990 ext prob =  0.050 for   100 years                      0.066 for  100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00            0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   81.485, lat   27.589
 shortest dist to fault= 9999.999 km
        zero attenuation variability                       variability in atten, sigma= 0.50
   g.m.   occ/yr    exc/yr  r(events) r(yrs)       g.m.   occ/yr    exc/yr  r(events) r(yrs)
    0.02  0.18967  0.00073    262.3   1377.5        0.02  0.18956  0.00084    227.2   1193.1
    0.04  0.00051  0.00022    865.8   4547.5        0.04  0.00054  0.00030    632.4   3321.5
    0.06  0.00017  0.00005   3819.6  20060.7        0.06  0.00017  0.00013   1509.3   7927.2
    0.08  0.00004  0.00001  33174.1  99999.9        0.08  0.00007  0.00006   3272.9  17189.8
    0.10  0.00001  0.00000  99999.9  99999.9        0.10  0.00003  0.00003   6648.3  34917.4
    0.12  0.00000  0.00000  99999.9  99999.9        0.12  0.00001  0.00001  12856.7  67524.6
    0.14  0.00000  0.00000  99999.9  99999.9        0.14  0.00001  0.00001  23892.4  99999.9
    0.16  0.00000  0.00000  99999.9  99999.9        0.16  0.00000  0.00000  42924.9  99999.9
    0.18  0.00000  0.00000  99999.9  99999.9        0.18  0.00000  0.00000  74866.1  99999.9
    0.20  0.00000  0.00000  99999.9  99999.9        0.20  0.00000  0.00000  99999.9  99999.9
  total yearly events    0.19040                  total yearly events    0.19040

        zero attenuation variability                       variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                      0.000 for    1 years
    0.990 ext prob =  0.041 for    50 years                      0.049 for   50 years
    0.990 ext prob =  0.051 for   100 years                      0.066 for  100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00            0.00
```

Peninsular Florida Seismic Hazard
site at long 80.810, lat 27.578
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18967	0.00073	262.4	1378.4
0.04	0.00051	0.00022	867.6	4556.7
0.06	0.00017	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18956	0.00084	227.4	1194.5
0.04	0.00054	0.00030	633.2	3325.5
0.06	0.00017	0.00013	1511.3	7937.4
0.08	0.00007	0.00006	3277.1	17211.7
0.10	0.00003	0.00003	6656.3	34959.5
0.12	0.00001	0.00001	12870.9	67599.2
0.14	0.00001	0.00001	23916.3	99999.9
0.16	0.00000	0.00000	42963.6	99999.9
0.18	0.00000	0.00000	74926.7	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.041 for 50 years	0.049 for 50 years
0.990 ext prob =	0.051 for 100 years	0.066 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.135, lat 27.563
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18968	0.00072	263.6	1384.7
0.04	0.00051	0.00022	880.9	4626.6
0.06	0.00017	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18957	0.00083	229.4	1204.6
0.04	0.00053	0.00030	638.8	3355.2
0.06	0.00017	0.00012	1525.8	8013.9
0.08	0.00007	0.00006	3308.6	17377.1
0.10	0.00003	0.00003	6716.6	35276.2
0.12	0.00001	0.00001	12977.7	68160.2
0.14	0.00001	0.00001	24095.7	99999.9
0.16	0.00000	0.00000	43253.3	99999.9
0.18	0.00000	0.00000	75380.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.041 for 50 years	0.049 for 50 years
0.990 ext prob =	0.050 for 100 years	0.066 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.838, lat 27.004
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4
0.04	0.00051	0.00020	940.4	4939.1
0.06	0.00015	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

```
Peninsular Florida Seismic Hazard
 site at long   82.167, lat   26.999
 shortest dist to fault= 9999.999 km
        zero attenuation variability                     variability in atten, sigma= 0.50
    g.m.   occ/yr     exc/yr  r(events) r(yrs)       g.m.   occ/yr     exc/yr  r(events) r(yrs)
     0.02  0.18969  0.00071    268.7  1411.4          0.02  0.18960  0.00080    237.5  1247.6
     0.04  0.00051  0.00020    940.4  4939.0          0.04  0.00051  0.00029    663.0  3482.2
     0.06  0.00015  0.00005   3819.6 20060.7          0.06  0.00017  0.00012   1588.8  8344.6
     0.08  0.00004  0.00001  33174.1 99999.9          0.08  0.00006  0.00006   3445.0 18093.4
     0.10  0.00001  0.00000  99999.9 99999.9          0.10  0.00003  0.00003   6977.2 36644.9
     0.12  0.00000  0.00000  99999.9 99999.9          0.12  0.00001  0.00001  13437.7 70576.2
     0.14  0.00000  0.00000  99999.9 99999.9          0.14  0.00001  0.00001  24865.4 99999.9
     0.16  0.00000  0.00000  99999.9 99999.9          0.16  0.00000  0.00000  44491.4 99999.9
     0.18  0.00000  0.00000  99999.9 99999.9          0.18  0.00000  0.00000  77314.8 99999.9
     0.20  0.00000  0.00000  99999.9 99999.9          0.20  0.00000  0.00000  99999.9 99999.9
  total yearly events    0.19040                   total yearly events    0.19040

        zero attenuation variability                     variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                        0.000 for     1 years
    0.990 ext prob =  0.040 for    50 years                        0.048 for    50 years
    0.990 ext prob =  0.050 for   100 years                        0.065 for   100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00          0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   81.496, lat   26.991
 shortest dist to fault= 9999.999 km
        zero attenuation variability                     variability in atten, sigma= 0.50
    g.m.   occ/yr     exc/yr  r(events) r(yrs)       g.m.   occ/yr     exc/yr  r(events) r(yrs)
     0.02  0.18969  0.00071    268.6  1410.9          0.02  0.18960  0.00080    237.4  1246.9
     0.04  0.00051  0.00020    939.2  4932.6          0.04  0.00051  0.00029    662.6  3479.8
     0.06  0.00015  0.00005   3819.6 20060.7          0.06  0.00017  0.00012   1587.6  8338.2
     0.08  0.00004  0.00001  33174.1 99999.9          0.08  0.00006  0.00006   3442.3 18079.2
     0.10  0.00001  0.00000  99999.9 99999.9          0.10  0.00003  0.00003   6972.0 36617.5
     0.12  0.00000  0.00000  99999.9 99999.9          0.12  0.00001  0.00001  13428.5 70527.9
     0.14  0.00000  0.00000  99999.9 99999.9          0.14  0.00001  0.00001  24850.0 99999.9
     0.16  0.00000  0.00000  99999.9 99999.9          0.16  0.00000  0.00000  44466.8 99999.9
     0.18  0.00000  0.00000  99999.9 99999.9          0.18  0.00000  0.00000  77276.3 99999.9
     0.20  0.00000  0.00000  99999.9 99999.9          0.20  0.00000  0.00000  99999.9 99999.9
  total yearly events    0.19040                   total yearly events    0.19040

        zero attenuation variability                     variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                        0.000 for     1 years
    0.990 ext prob =  0.040 for    50 years                        0.048 for    50 years
    0.990 ext prob =  0.050 for   100 years                        0.065 for   100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00          0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   80.825, lat   26.979
 shortest dist to fault= 9999.999 km
        zero attenuation variability                     variability in atten, sigma= 0.50
    g.m.   occ/yr     exc/yr  r(events) r(yrs)       g.m.   occ/yr     exc/yr  r(events) r(yrs)
     0.02  0.18969  0.00071    268.6  1410.8          0.02  0.18960  0.00080    237.4  1246.9
     0.04  0.00051  0.00020    939.1  4932.2          0.04  0.00051  0.00029    662.5  3479.7
     0.06  0.00015  0.00005   3819.6 20060.7          0.06  0.00017  0.00012   1587.5  8337.8
     0.08  0.00004  0.00001  33174.1 99999.9          0.08  0.00006  0.00006   3442.1 18078.3
     0.10  0.00001  0.00000  99999.9 99999.9          0.10  0.00003  0.00003   6971.7 36615.8
     0.12  0.00000  0.00000  99999.9 99999.9          0.12  0.00001  0.00001  13427.9 70524.9
     0.14  0.00000  0.00000  99999.9 99999.9          0.14  0.00001  0.00001  24849.1 99999.9
     0.16  0.00000  0.00000  99999.9 99999.9          0.16  0.00000  0.00000  44465.2 99999.9
     0.18  0.00000  0.00000  99999.9 99999.9          0.18  0.00000  0.00000  77274.0 99999.9
     0.20  0.00000  0.00000  99999.9 99999.9          0.20  0.00000  0.00000  99999.9 99999.9
  total yearly events    0.19040                   total yearly events    0.19040

        zero attenuation variability                     variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                        0.000 for     1 years
    0.990 ext prob =  0.040 for    50 years                        0.048 for    50 years
    0.990 ext prob =  0.050 for   100 years                        0.065 for   100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00          0.00
```

Peninsular Florida Seismic Hazard
site at long 80.154, lat 26.965
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4	0.02	0.18960	0.00080	237.5	1247.6
0.04	0.00051	0.00020	940.3	4938.7	0.04	0.00051	0.00029	663.0	3482.0
0.06	0.00015	0.00005	3819.6	20060.7	0.06	0.00017	0.00012	1588.7	8344.3
0.08	0.00004	0.00001	33174.1	99999.9	0.08	0.00006	0.00006	3444.8	18092.6
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00003	0.00003	6976.9	36643.4
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00001	0.00001	13437.2	70573.5
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	24864.5	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00000	44490.0	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	77312.6	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040 — total yearly events 0.19040

zero attenuation variability — variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=

	zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.842, lat 26.406
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4	0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00020	940.4	4939.1	0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00015	0.00005	3819.6	20060.7	0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00004	0.00001	33174.1	99999.9	0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040 — total yearly events 0.19040

zero attenuation variability — variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=

	zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.174, lat 26.401
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4	0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00020	940.4	4939.1	0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00015	0.00005	3819.6	20060.7	0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00004	0.00001	33174.1	99999.9	0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040 — total yearly events 0.19040

zero attenuation variability — variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=

	zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 81.507, lat 26.393
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4	0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00020	940.4	4939.1	0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00015	0.00005	3819.6	20060.7	0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00004	0.00001	33174.1	99999.9	0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability / variability in atten, sigma=0.50

sol not obtained for time=
sol not obtained for time=

	zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.839, lat 26.381
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4	0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00020	940.4	4939.1	0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00015	0.00005	3819.6	20060.7	0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00004	0.00001	33174.1	99999.9	0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability / variability in atten, sigma=0.50

sol not obtained for time=
sol not obtained for time=

	zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.172, lat 26.367
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4	0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00020	940.4	4939.1	0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00015	0.00005	3819.6	20060.7	0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00004	0.00001	33174.1	99999.9	0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability / variability in atten, sigma=0.50

sol not obtained for time=
sol not obtained for time=

	zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

```
Peninsular Florida Seismic Hazard
 site at long   82.845, lat   25.808
 shortest dist to fault= 9999.999 km
         zero attenuation variability                  variability in atten, sigma= 0.50
   g.m.    occ/yr    exc/yr  r(events) r(yrs)      g.m.    occ/yr    exc/yr  r(events) r(yrs)
   0.02  0.18969  0.00071    268.7   1411.4        0.02  0.18960  0.00080    237.6   1247.6
   0.04  0.00051  0.00020    940.4   4939.1        0.04  0.00051  0.00029    663.0   3482.2
   0.06  0.00015  0.00005   3819.6  20060.7        0.06  0.00017  0.00012   1588.8   8344.7
   0.08  0.00004  0.00001  33174.1  99999.9        0.08  0.00006  0.00006   3445.0  18093.6
   0.10  0.00001  0.00000  99999.9  99999.9        0.10  0.00003  0.00003   6977.3  36645.3
   0.12  0.00000  0.00000  99999.9  99999.9        0.12  0.00001  0.00001  13437.8  70576.9
   0.14  0.00000  0.00000  99999.9  99999.9        0.14  0.00001  0.00001  24865.6  99999.9
   0.16  0.00000  0.00000  99999.9  99999.9        0.16  0.00000  0.00000  44491.8  99999.9
   0.18  0.00000  0.00000  99999.9  99999.9        0.18  0.00000  0.00000  77315.3  99999.9
   0.20  0.00000  0.00000  99999.9  99999.9        0.20  0.00000  0.00000  99999.9  99999.9
  total yearly events     0.19040                total yearly events     0.19040

         zero attenuation variability                  variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                  0.000 for    1 years
    0.990 ext prob =  0.040 for    50 years                  0.048 for   50 years
    0.990 ext prob =  0.050 for   100 years                  0.065 for  100 years
  ratio  100 yr 0.990 extreme value to     1 yr val   =   0.00          0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   82.181, lat   25.803
 shortest dist to fault= 9999.999 km
         zero attenuation variability                  variability in atten, sigma= 0.50
   g.m.    occ/yr    exc/yr  r(events) r(yrs)      g.m.    occ/yr    exc/yr  r(events) r(yrs)
   0.02  0.18969  0.00071    268.7   1411.4        0.02  0.18960  0.00080    237.6   1247.6
   0.04  0.00051  0.00020    940.4   4939.1        0.04  0.00051  0.00029    663.0   3482.2
   0.06  0.00015  0.00005   3819.6  20060.7        0.06  0.00017  0.00012   1588.8   8344.7
   0.08  0.00004  0.00001  33174.1  99999.9        0.08  0.00006  0.00006   3445.0  18093.6
   0.10  0.00001  0.00000  99999.9  99999.9        0.10  0.00003  0.00003   6977.3  36645.3
   0.12  0.00000  0.00000  99999.9  99999.9        0.12  0.00001  0.00001  13437.8  70576.9
   0.14  0.00000  0.00000  99999.9  99999.9        0.14  0.00001  0.00001  24865.6  99999.9
   0.16  0.00000  0.00000  99999.9  99999.9        0.16  0.00000  0.00000  44491.8  99999.9
   0.18  0.00000  0.00000  99999.9  99999.9        0.18  0.00000  0.00000  77315.3  99999.9
   0.20  0.00000  0.00000  99999.9  99999.9        0.20  0.00000  0.00000  99999.9  99999.9
  total yearly events     0.19040                total yearly events     0.19040

         zero attenuation variability                  variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                  0.000 for    1 years
    0.990 ext prob =  0.040 for    50 years                  0.048 for   50 years
    0.990 ext prob =  0.050 for   100 years                  0.065 for  100 years
  ratio  100 yr 0.990 extreme value to     1 yr val   =   0.00          0.00
```

```
Peninsular Florida Seismic Hazard
 site at long   81.518, lat   25.795
 shortest dist to fault= 9999.999 km
         zero attenuation variability                  variability in atten, sigma= 0.50
   g.m.    occ/yr    exc/yr  r(events) r(yrs)      g.m.    occ/yr    exc/yr  r(events) r(yrs)
   0.02  0.18969  0.00071    268.7   1411.4        0.02  0.18960  0.00080    237.6   1247.6
   0.04  0.00051  0.00020    940.4   4939.1        0.04  0.00051  0.00029    663.0   3482.2
   0.06  0.00015  0.00005   3819.6  20060.7        0.06  0.00017  0.00012   1588.8   8344.7
   0.08  0.00004  0.00001  33174.1  99999.9        0.08  0.00006  0.00006   3445.0  18093.6
   0.10  0.00001  0.00000  99999.9  99999.9        0.10  0.00003  0.00003   6977.3  36645.3
   0.12  0.00000  0.00000  99999.9  99999.9        0.12  0.00001  0.00001  13437.8  70576.9
   0.14  0.00000  0.00000  99999.9  99999.9        0.14  0.00001  0.00001  24865.6  99999.9
   0.16  0.00000  0.00000  99999.9  99999.9        0.16  0.00000  0.00000  44491.8  99999.9
   0.18  0.00000  0.00000  99999.9  99999.9        0.18  0.00000  0.00000  77315.3  99999.9
   0.20  0.00000  0.00000  99999.9  99999.9        0.20  0.00000  0.00000  99999.9  99999.9
  total yearly events     0.19040                total yearly events     0.19040

         zero attenuation variability                  variability in atten, sigma=0.50
 sol not obtained for time=
 sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                  0.000 for    1 years
    0.990 ext prob =  0.040 for    50 years                  0.048 for   50 years
    0.990 ext prob =  0.050 for   100 years                  0.065 for  100 years
  ratio  100 yr 0.990 extreme value to     1 yr val   =   0.00          0.00
```

Peninsular Florida Seismic Hazard
site at long 80.854, lat 25.783
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4
0.04	0.00051	0.00020	940.4	4939.1
0.06	0.00015	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 80.190, lat 25.769
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4
0.04	0.00051	0.00020	940.4	4939.1
0.06	0.00015	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.849, lat 25.209
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4
0.04	0.00051	0.00020	940.4	4939.1
0.06	0.00015	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.040 for 50 years	0.048 for 50 years
0.990 ext prob =	0.050 for 100 years	0.065 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Peninsular Florida Seismic Hazard
site at long 82.189, lat 25.205
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4
0.04	0.00051	0.00020	940.4	4939.1
0.06	0.00015	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years
0.990 ext prob = 0.040 for 50 years
0.990 ext prob = 0.050 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00

variability in atten, sigma=0.50
0.000 for 1 years
0.048 for 50 years
0.065 for 100 years
0.00

Peninsular Florida Seismic Hazard
site at long 81.528, lat 25.197
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18969	0.00071	268.7	1411.4
0.04	0.00051	0.00020	940.4	4939.1
0.06	0.00015	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18960	0.00080	237.6	1247.6
0.04	0.00051	0.00029	663.0	3482.2
0.06	0.00017	0.00012	1588.8	8344.7
0.08	0.00006	0.00006	3445.0	18093.6
0.10	0.00003	0.00003	6977.3	36645.3
0.12	0.00001	0.00001	13437.8	70576.9
0.14	0.00001	0.00001	24865.6	99999.9
0.16	0.00000	0.00000	44491.8	99999.9
0.18	0.00000	0.00000	77315.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years
0.990 ext prob = 0.040 for 50 years
0.990 ext prob = 0.050 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00

variability in atten, sigma=0.50
0.000 for 1 years
0.048 for 50 years
0.065 for 100 years
0.00

Peninsular Florida Seismic Hazard
site at long 80.868, lat 25.185
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18968	0.00072	265.5	1394.4
0.04	0.00051	0.00021	901.9	4736.8
0.06	0.00016	0.00005	3617.5	18999.3
0.08	0.00004	0.00001	22336.2	99999.9
0.10	0.00001	0.00000	67834.5	99999.9
0.12	0.00000	0.00000	68369.9	99999.9
0.14	0.00000	0.00000	68369.9	99999.9
0.16	0.00000	0.00000	68369.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9
0.22	0.00000	0.00000	99999.9	99999.9
0.24	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18959	0.00081	233.8	1228.0
0.04	0.00052	0.00029	647.2	3399.2
0.06	0.00017	0.00012	1527.7	8023.5
0.08	0.00007	0.00006	3233.9	16984.9
0.10	0.00003	0.00003	6302.6	33101.8
0.12	0.00001	0.00002	11449.8	60135.7
0.14	0.00001	0.00001	19510.7	99999.9
0.16	0.00000	0.00001	31323.2	99999.9
0.18	0.00000	0.00000	47610.3	99999.9
0.20	0.00000	0.00000	68954.2	99999.9
0.22	0.00000	0.00000	95821.7	99999.9
0.24	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years
0.990 ext prob = 0.041 for 50 years
0.990 ext prob = 0.051 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00

variability in atten, sigma=0.50
0.000 for 1 years
0.049 for 50 years
0.066 for 100 years
0.00

Peninsular Florida Seismic Hazard
site at long 80.208, lat 25.171
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18963	0.00077	245.7	1290.4	0.02	0.18949	0.00091	209.1	1098.0
0.04	0.00051	0.00027	708.0	3718.5	0.04	0.00057	0.00034	554.8	2913.8
0.06	0.00020	0.00007	2672.3	14035.0	0.06	0.00019	0.00016	1212.4	6367.6
0.08	0.00004	0.00003	7015.2	36844.7	0.08	0.00007	0.00008	2292.4	12040.2
0.10	0.00001	0.00002	8887.4	46677.7	0.10	0.00003	0.00005	3827.0	20099.9
0.12	0.00000	0.00002	8896.6	46725.6	0.12	0.00002	0.00003	5756.1	30231.4
0.14	0.00000	0.00002	8896.6	46725.6	0.14	0.00001	0.00002	7997.1	42001.7
0.16	0.00000	0.00002	8896.6	46725.6	0.16	0.00001	0.00002	10516.1	55231.5
0.18	0.00002	0.00001	33806.9	99999.9	0.18	0.00000	0.00001	13342.1	70074.3
0.20	0.00000	0.00001	33806.9	99999.9	0.20	0.00000	0.00001	16551.4	86929.7
0.22	0.00000	0.00001	33806.9	99999.9	0.22	0.00000	0.00001	20244.0	99999.9
0.24	0.00000	0.00001	33806.9	99999.9	0.24	0.00000	0.00001	24535.4	99999.9
0.26	0.00000	0.00001	33806.9	99999.9	0.26	0.00000	0.00001	29553.9	99999.9
0.28	0.00001	0.00000	99999.9	99999.9	0.28	0.00000	0.00001	35434.1	99999.9
0.30	0.00000	0.00000	99999.9	99999.9	0.30	0.00000	0.00000	42342.2	99999.9
0.32	0.00000	0.00000	99999.9	99999.9	0.32	0.00000	0.00000	50456.5	99999.9
0.34	0.00000	0.00000	99999.9	99999.9	0.34	0.00000	0.00000	59979.3	99999.9
0.36	0.00000	0.00000	99999.9	99999.9	0.36	0.00000	0.00000	71140.3	99999.9
0.38	0.00000	0.00000	99999.9	99999.9	0.38	0.00000	0.00000	84201.0	99999.9
0.40	0.00000	0.00000	99999.9	99999.9	0.40	0.00000	0.00000	99458.7	99999.9
0.42	0.00000	0.00000	99999.9	99999.9	0.42	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability — variability in atten, sigma=0.50

sol not obtained for time=
sol not obtained for time=

	zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.044 for 50 years	0.054 for 50 years
0.990 ext prob =	0.055 for 100 years	0.074 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

```
Florida Panhandle Seismic Hazard
 isw=0: new run--no previous results included
 extreme probability  0.990
   for exposure times (years)      1   50  100
 scale factor for ground motion "box" levels=   1.00
 coordinates input in decimal degrees
   coordinates are printed in decimal degrees
 variability in attenuation, sigma=  0.50
 grid oriented parallel to great circle thru (  87.00, 28.00),(  80.00, 28.00)
 corners of gridded area-upper left=  87.00,  31.15
                         lower right=  80.00,  25.00
 longitude increment= 0.5982 (decimal degrees)
 latitude increment = 0.5982 (decimal degrees)
 gridded region contains  11 rows,   11 cols including border    0 rows and cols
 for this run begin at row   1 end row   4, begin col   1 end col   7
 new coordinates (km) gridded area
      upper left=   677.85    -9.60; lower right=   350.50  -333.81
 sites are also located on   0 line(s)
 attenuation function Fla-Region
                                  magnitude
   dist(km)     6.70       5.50       4.00
      80.00   0.15000   0.03450   0.00700
     130.00   0.05000   0.01640   0.00150
     240.00   0.03000   0.00480   0.00026
     360.00   0.01500   0.00164   0.00003
     580.00   0.00700   0.00030   0.00001

yrnoc=      1. iprint=-1 for area Char
     82.300    33.100    81.300    34.300
     81.000    32.100    79.700    33.500
 nr of levels of seismicity =  3
 Char beta= -1.0217
 earthquake rate / year
 occurrences=  0.000500  0.000300  0.000100
  magnitudes=      6.50      7.00      7.40
 Char area=   30369. sq km, rate/sq km= 0.16464E-07 for mags  6.25- 6.75

yrnoc=      1. iprint=-1 for area Pied
     80.300    37.500    77.000    37.500
     82.000    36.000    77.000    36.000
     87.000    32.000    79.700    32.000
 nr of levels of seismicity =  3
 Pied beta= -1.8388
 earthquake rate / year
 occurrences=  0.012500  0.007200  0.005000
  magnitudes=      5.50      5.80      6.00
 Pied area=  316141. sq km, rate/sq km= 0.39539E-07 for mags  5.35- 5.65

yrnoc=      1. iprint=-1 for area SApp
     82.800    37.500    80.300    37.500
     88.500    32.000    87.000    32.000
 nr of levels of seismicity =  3
 SApp beta= -2.0205
 earthquake rate / year
 occurrences=  0.002200  0.001200  0.000800
  magnitudes=      6.50      6.80      7.00
 SApp area=  111353. sq km, rate/sq km= 0.19757E-07 for mags  6.35- 6.65

yrnoc=      1. iprint=-1 for area NMad
     87.400    38.000    86.000    38.000
     90.300    35.300    88.000    35.300
 nr of levels of seismicity =  3
 NMad beta= -1.9330
 earthquake rate / year
 occurrences=  0.001300  0.000600  0.000200
  magnitudes=      7.40      7.80      8.30
 NMad area=   50440. sq km, rate/sq km= 0.25773E-07 for mags  7.20- 7.60

yrnoc=      1. iprint=-1 for area Caym
     86.700    18.500    77.000    20.700
     86.700    17.000    77.000    17.000
 nr of levels of seismicity =  4
 Caym beta= -2.1466
 earthquake rate / year
 occurrences=  0.011700  0.004000  0.001400  0.000500
  magnitudes=      7.00      7.50      8.00      8.50
 Caym area=  301315. sq km, rate/sq km= 0.38830E-07 for mags  6.75- 7.25

yrnoc=      1. iprint= 2 for area Flor
     90.000    32.000    77.000    32.000
     90.000    22.000    77.000    22.000
     86.000    18.700    77.000    20.700
 nr of levels of seismicity =  4
 Flor beta= -1.2681
 earthquake rate / year
 occurrences=  0.064600  0.038900  0.023400  0.014000
  magnitudes=      3.80      4.20      4.60      5.00
 Flor area= 1760366. sq km, rate/sq km= 0.36697E-07 for mags  3.60- 4.00
```

Florida Panhandle Seismic Hazard
site at long 87.000, lat 31.150
shortest dist to fault= 9999.999 km

	zero attenuation variability				variability in atten, sigma= 0.50			
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18754	0.00286	66.6	349.7	0.18733	0.00307	62.0	325.8
0.04	0.00141	0.00145	131.0	688.0	0.00159	0.00148	128.4	674.6
0.06	0.00102	0.00044	437.5	2297.9	0.00067	0.00081	234.4	1231.3
0.08	0.00011	0.00033	580.9	3050.9	0.00032	0.00049	386.0	2027.5
0.10	0.00002	0.00031	610.0	3203.9	0.00017	0.00033	584.5	3069.7
0.12	0.00023	0.00008	2441.5	12823.0	0.00010	0.00023	831.0	4364.5
0.14	0.00000	0.00008	2474.6	12997.0	0.00006	0.00017	1129.2	5930.9
0.16	0.00000	0.00008	2479.8	13024.2	0.00004	0.00013	1485.5	7801.9
0.18	0.00000	0.00008	2479.8	13024.2	0.00003	0.00010	1908.5	10023.9
0.20	0.00000	0.00008	2479.8	13024.2	0.00002	0.00008	2409.9	12656.9
0.22	0.00000	0.00008	2479.8	13024.2	0.00002	0.00006	3003.6	15775.1
0.24	0.00008	0.00000	99999.9	99999.9	0.00001	0.00005	3706.7	19468.1
0.26	0.00000	0.00000	99999.9	99999.9	0.00001	0.00004	4539.7	23842.7
0.28	0.00000	0.00000	99999.9	99999.9	0.00001	0.00003	5525.8	29022.3
0.30	0.00000	0.00000	99999.9	99999.9	0.00001	0.00003	6693.8	35156.5
0.32	0.00000	0.00000	99999.9	99999.9	0.00000	0.00002	8076.2	42417.1
0.34	0.00000	0.00000	99999.9	99999.9	0.00000	0.00002	9711.1	51003.8
0.36	0.00000	0.00000	99999.9	99999.9	0.00000	0.00002	11642.6	61147.9
0.38	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	13921.5	73117.4
0.40	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	16607.0	87221.7
0.42	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	19766.8	99999.9
0.44	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	23479.2	99999.9
0.46	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	27834.1	99999.9
0.48	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	32927.4	99999.9
0.50	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	38882.6	99999.9
0.52	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	45834.2	99999.9
0.54	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	53935.8	99999.9
0.56	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	63363.0	99999.9
0.58	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	74315.5	99999.9
0.60	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	87020.5	99999.9
0.62	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				0.19040			

zero attenuation variability — variability in atten, sigma=0.50

sol not obtained for time=
sol not obtained for time=

	zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.106 for 50 years	0.129 for 50 years
0.990 ext prob =	0.116 for 100 years	0.179 for 100 years

ratio 100 yr 0.990 extreme value to 1 yr val = 0.00 0.00

Florida Panhandle Seismic Hazard
site at long 86.302, lat 31.165
shortest dist to fault= 9999.999 km

	zero attenuation variability				variability in atten, sigma= 0.50			
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18745	0.00295	64.6	339.2	0.18716	0.00324	58.8	308.8
0.04	0.00174	0.00121	157.5	827.3	0.00186	0.00138	138.0	725.0
0.06	0.00091	0.00030	637.3	3347.2	0.00069	0.00069	277.3	1456.3
0.08	0.00007	0.00023	838.4	4403.5	0.00030	0.00039	488.0	2562.9
0.10	0.00001	0.00022	862.8	4531.3	0.00014	0.00025	771.9	4054.2
0.12	0.00017	0.00006	3451.4	18127.2	0.00008	0.00017	1127.8	5923.4
0.14	0.00000	0.00006	3451.4	18127.2	0.00005	0.00012	1557.3	8179.1
0.16	0.00000	0.00006	3451.4	18127.2	0.00003	0.00009	2067.0	10855.9
0.18	0.00000	0.00006	3451.4	18127.2	0.00002	0.00007	2668.0	14012.7
0.20	0.00000	0.00006	3451.4	18127.2	0.00001	0.00006	3376.3	17732.6
0.22	0.00000	0.00006	3451.4	18127.2	0.00001	0.00005	4211.6	22119.8
0.24	0.00006	0.00000	99999.9	99999.9	0.00001	0.00004	5198.1	27300.7
0.26	0.00000	0.00000	99999.9	99999.9	0.00001	0.00003	6364.3	33426.0
0.28	0.00000	0.00000	99999.9	99999.9	0.00001	0.00002	7742.8	40666.0
0.30	0.00000	0.00000	99999.9	99999.9	0.00000	0.00002	9374.0	49233.1
0.32	0.00000	0.00000	99999.9	99999.9	0.00000	0.00002	11303.6	59367.4
0.34	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	13584.6	71347.8
0.36	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	16278.6	85496.9
0.38	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	19456.7	99999.9
0.40	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	23201.0	99999.9
0.42	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	27606.1	99999.9
0.44	0.00000	0.00000	99999.9	99999.9	0.00000	0.00001	32781.1	99999.9
0.46	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	38851.3	99999.9
0.48	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	45948.0	99999.9
0.50	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	54244.9	99999.9
0.52	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	63929.3	99999.9
0.54	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	75215.2	99999.9
0.56	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	88346.8	99999.9
0.58	0.00000	0.00000	99999.9	99999.9	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				0.19040			

zero attenuation variability — variability in atten, sigma=0.50

sol not obtained for time=
sol not obtained for time=

	zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.101 for 50 years	0.111 for 50 years
0.990 ext prob =	0.111 for 100 years	0.154 for 100 years

ratio 100 yr 0.990 extreme value to 1 yr val = 0.00 0.00

Florida Panhandle Seismic Hazard
site at long 85.604, lat 31.177
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18763	0.00277	68.8	361.5	0.02	0.18721	0.00319	59.6	313.2
0.04	0.00190	0.00086	220.1	1156.2	0.04	0.00202	0.00117	162.7	854.7
0.06	0.00069	0.00017	1119.5	5880.0	0.06	0.00065	0.00052	368.7	1936.7
0.08	0.00004	0.00013	1520.5	7985.8	0.08	0.00025	0.00027	713.1	3745.4
0.10	0.00001	0.00012	1593.2	8367.9	0.10	0.00011	0.00016	1211.6	6363.7
0.12	0.00009	0.00003	6374.1	33477.7	0.12	0.00005	0.00010	1864.0	9790.0
0.14	0.00000	0.00003	6374.1	33477.7	0.14	0.00003	0.00007	2667.5	14009.7
0.16	0.00000	0.00003	6374.1	33477.7	0.16	0.00002	0.00005	3626.6	19047.4
0.18	0.00000	0.00003	6374.1	33477.7	0.18	0.00001	0.00004	4756.7	24982.7
0.20	0.00000	0.00003	6374.1	33477.7	0.20	0.00001	0.00003	6084.2	31954.7
0.22	0.00000	0.00003	6374.1	33477.7	0.22	0.00001	0.00002	7644.3	40148.8
0.24	0.00003	0.00000	99999.9	99999.9	0.24	0.00000	0.00002	9481.4	49797.1
0.26	0.00000	0.00000	99999.9	99999.9	0.26	0.00000	0.00002	11648.4	61178.7
0.28	0.00000	0.00000	99999.9	99999.9	0.28	0.00000	0.00001	14203.5	74598.4
0.30	0.00000	0.00000	99999.9	99999.9	0.30	0.00000	0.00001	17223.8	90461.3
0.32	0.00000	0.00000	99999.9	99999.9	0.32	0.00000	0.00001	20794.0	99999.9
0.34	0.00000	0.00000	99999.9	99999.9	0.34	0.00000	0.00001	25012.3	99999.9
0.36	0.00000	0.00000	99999.9	99999.9	0.36	0.00000	0.00001	29992.7	99999.9
0.38	0.00000	0.00000	99999.9	99999.9	0.38	0.00000	0.00001	35866.7	99999.9
0.40	0.00000	0.00000	99999.9	99999.9	0.40	0.00000	0.00000	42786.3	99999.9
0.42	0.00000	0.00000	99999.9	99999.9	0.42	0.00000	0.00000	50926.7	99999.9
0.44	0.00000	0.00000	99999.9	99999.9	0.44	0.00000	0.00000	60489.8	99999.9
0.46	0.00000	0.00000	99999.9	99999.9	0.46	0.00000	0.00000	71707.4	99999.9
0.48	0.00000	0.00000	99999.9	99999.9	0.48	0.00000	0.00000	84813.1	99999.9
0.50	0.00000	0.00000	99999.9	99999.9	0.50	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability — variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years — 0.000 for 1 years
0.990 ext prob = 0.058 for 50 years — 0.091 for 50 years
0.990 ext prob = 0.102 for 100 years — 0.121 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00 — 0.00

Florida Panhandle Seismic Hazard
site at long 84.906, lat 31.186
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18793	0.00247	77.2	405.4	0.02	0.18739	0.00301	63.2	331.9
0.04	0.00196	0.00051	374.5	1966.8	0.04	0.00208	0.00093	204.6	1074.5
0.06	0.00042	0.00009	2143.7	11259.1	0.06	0.00058	0.00035	540.4	2838.1
0.08	0.00004	0.00004	4332.5	22755.0	0.08	0.00019	0.00016	1201.7	6311.6
0.10	0.00001	0.00004	4980.5	26158.3	0.10	0.00008	0.00008	2318.2	12175.5
0.12	0.00003	0.00001	19933.5	99999.9	0.12	0.00003	0.00005	3985.5	20932.1
0.14	0.00000	0.00001	19933.5	99999.9	0.14	0.00002	0.00003	6253.8	32845.6
0.16	0.00000	0.00001	19933.5	99999.9	0.16	0.00001	0.00002	9143.3	48021.6
0.18	0.00000	0.00001	19933.5	99999.9	0.18	0.00001	0.00002	12671.8	66553.6
0.20	0.00000	0.00001	19933.5	99999.9	0.20	0.00000	0.00001	16886.6	88690.3
0.22	0.00000	0.00001	19933.5	99999.9	0.22	0.00000	0.00001	21866.8	99999.9
0.24	0.00001	0.00000	99999.9	99999.9	0.24	0.00000	0.00001	27729.4	99999.9
0.26	0.00000	0.00000	99999.9	99999.9	0.26	0.00000	0.00001	34628.5	99999.9
0.28	0.00000	0.00000	99999.9	99999.9	0.28	0.00000	0.00000	42711.5	99999.9
0.30	0.00000	0.00000	99999.9	99999.9	0.30	0.00000	0.00000	52241.3	99999.9
0.32	0.00000	0.00000	99999.9	99999.9	0.32	0.00000	0.00000	63481.6	99999.9
0.34	0.00000	0.00000	99999.9	99999.9	0.34	0.00000	0.00000	76740.5	99999.9
0.36	0.00000	0.00000	99999.9	99999.9	0.36	0.00000	0.00000	92375.2	99999.9
0.38	0.00000	0.00000	99999.9	99999.9	0.38	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability — variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years — 0.000 for 1 years
0.990 ext prob = 0.051 for 50 years — 0.074 for 50 years
0.990 ext prob = 0.059 for 100 years — 0.094 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00 — 0.00

Florida Panhandle Seismic Hazard
site at long 84.208, lat 31.191
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18826	0.00214	89.1	467.7	0.02	0.18759	0.00281	67.7	355.7
0.04	0.00182	0.00032	590.9	3103.5	0.04	0.00204	0.00077	247.2	1298.1
0.06	0.00025	0.00007	2572.6	13511.8	0.06	0.00051	0.00026	721.1	3787.1
0.08	0.00007	0.00001	32824.4	99999.9	0.08	0.00016	0.00011	1788.9	9395.3
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00006	0.00005	3957.8	20786.8
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	8082.7	42451.5
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	15576.9	81812.2
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00001	28707.4	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	50993.8	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	87928.0	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

zero attenuation variability — variability in atten, sigma=0.50

sol not obtained for time=
sol not obtained for time=

zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.046 for 50 years	0.066 for 50 years
0.990 ext prob = 0.056 for 100 years	0.081 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 83.510, lat 31.193
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18840	0.00201	94.7	497.4	0.02	0.18769	0.00272	69.9	367.4
0.04	0.00165	0.00036	524.0	2752.1	0.04	0.00196	0.00076	249.9	1312.6
0.06	0.00026	0.00010	1847.9	9704.9	0.06	0.00049	0.00028	688.3	3614.8
0.08	0.00009	0.00002	10920.1	57350.2	0.08	0.00016	0.00012	1603.2	8419.8
0.10	0.00002	0.00000	99999.9	99999.9	0.10	0.00006	0.00006	3348.9	17587.7
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00003	0.00003	6507.2	34174.9
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00002	12014.7	63098.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00001	21333.8	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00001	36687.6	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	61465.8	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19041				total yearly events	0.19041			

sol not obtained for time=
sol not obtained for time=

zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.049 for 50 years	0.068 for 50 years
0.990 ext prob = 0.060 for 100 years	0.085 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 82.812, lat 31.191
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18844	0.00195	97.4	511.6	0.02	0.18774	0.00265	71.7	376.8
0.04	0.00152	0.00043	439.4	2308.0	0.04	0.00187	0.00078	243.8	1280.6
0.06	0.00031	0.00013	1503.6	7897.0	0.06	0.00048	0.00030	629.6	3306.6
0.08	0.00009	0.00004	4615.1	24239.4	0.08	0.00016	0.00014	1381.3	7254.9
0.10	0.00004	0.00000	99999.9	99999.9	0.10	0.00007	0.00007	2742.2	14402.6
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00003	0.00004	5103.0	26801.8
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00002	0.00002	9075.4	47665.7
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00001	15591.1	81887.2
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00001	26036.2	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	42475.6	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	67910.6	99999.9
0.24	0.00000	0.00000	99999.9	99999.9	0.24	0.00000	0.00000	99999.9	99999.9
total yearly events	0.19040				total yearly events	0.19040			

sol not obtained for time=
sol not obtained for time=

zero attenuation variability	variability in atten, sigma=0.50
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.052 for 50 years	0.070 for 50 years
0.990 ext prob = 0.064 for 100 years	0.089 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 86.980, lat 30.552
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18866	0.00174	109.3	574.2	0.02	0.18847	0.00193	98.7	518.3
0.04	0.00120	0.00054	354.0	1859.2	0.04	0.00120	0.00072	262.8	1380.1
0.06	0.00043	0.00011	1692.9	8891.4	0.06	0.00040	0.00032	594.9	3124.5
0.08	0.00004	0.00007	2785.6	14630.3	0.08	0.00016	0.00016	1165.4	6120.6
0.10	0.00001	0.00006	3039.9	15965.9	0.10	0.00007	0.00009	2022.5	10622.4
0.12	0.00005	0.00002	12163.9	63885.8	0.12	0.00003	0.00006	3187.7	16742.0
0.14	0.00000	0.00002	12163.9	63885.8	0.14	0.00002	0.00004	4667.7	24515.2
0.16	0.00000	0.00002	12163.9	63885.8	0.16	0.00001	0.00003	6471.8	33990.4
0.18	0.00000	0.00002	12163.9	63885.8	0.18	0.00001	0.00002	8622.8	45287.8
0.20	0.00000	0.00002	12163.9	63885.8	0.20	0.00001	0.00002	11163.8	58633.2
0.22	0.00000	0.00002	12163.9	63885.8	0.22	0.00000	0.00001	14156.1	74349.1
0.24	0.00002	0.00000	99999.9	99999.9	0.24	0.00000	0.00001	17679.9	92856.6
0.26	0.00000	0.00000	99999.9	99999.9	0.26	0.00000	0.00001	21834.1	99999.9
0.28	0.00000	0.00000	99999.9	99999.9	0.28	0.00000	0.00001	26726.8	99999.9
0.30	0.00000	0.00000	99999.9	99999.9	0.30	0.00000	0.00001	32505.5	99999.9
0.32	0.00000	0.00000	99999.9	99999.9	0.32	0.00000	0.00000	39331.7	99999.9
0.34	0.00000	0.00000	99999.9	99999.9	0.34	0.00000	0.00000	47393.1	99999.9
0.36	0.00000	0.00000	99999.9	99999.9	0.36	0.00000	0.00000	56907.1	99999.9
0.38	0.00000	0.00000	99999.9	99999.9	0.38	0.00000	0.00000	68125.0	99999.9
0.40	0.00000	0.00000	99999.9	99999.9	0.40	0.00000	0.00000	81337.6	99999.9
0.42	0.00000	0.00000	99999.9	99999.9	0.42	0.00000	0.00000	96879.5	99999.9
0.44	0.00000	0.00000	99999.9	99999.9	0.44	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.053 for 50 years	0.074 for 50 years
0.990 ext prob = 0.065 for 100 years	0.098 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 86.286, lat 30.567
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18871	0.00169	112.4	590.1	0.02	0.18839	0.00201	94.5	496.5
0.04	0.00125	0.00045	423.7	2225.3	0.04	0.00134	0.00068	280.7	1474.1
0.06	0.00037	0.00008	2533.5	13306.1	0.06	0.00041	0.00027	697.4	3662.7
0.08	0.00004	0.00003	6133.2	32212.4	0.08	0.00015	0.00013	1506.7	7913.2
0.10	0.00001	0.00003	7517.8	39484.3	0.10	0.00006	0.00007	2901.7	15239.8
0.12	0.00002	0.00001	30097.4	99999.9	0.12	0.00003	0.00004	5069.1	26623.4
0.14	0.00000	0.00001	30097.4	99999.9	0.14	0.00001	0.00002	8152.2	42816.4
0.16	0.00000	0.00001	30097.4	99999.9	0.16	0.00001	0.00002	12239.3	64282.1
0.18	0.00000	0.00001	30097.4	99999.9	0.18	0.00000	0.00001	17383.6	91300.3
0.20	0.00000	0.00001	30097.4	99999.9	0.20	0.00000	0.00001	23651.5	99999.9
0.22	0.00000	0.00001	30097.4	99999.9	0.22	0.00000	0.00001	31142.9	99999.9
0.24	0.00001	0.00000	99999.9	99999.9	0.24	0.00000	0.00000	40011.3	99999.9
0.26	0.00000	0.00000	99999.9	99999.9	0.26	0.00000	0.00000	50470.1	99999.9
0.28	0.00000	0.00000	99999.9	99999.9	0.28	0.00000	0.00000	62734.3	99999.9
0.30	0.00000	0.00000	99999.9	99999.9	0.30	0.00000	0.00000	77185.5	99999.9
0.32	0.00000	0.00000	99999.9	99999.9	0.32	0.00000	0.00000	94217.7	99999.9
0.34	0.00000	0.00000	99999.9	99999.9	0.34	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.049 for 50 years	0.068 for 50 years
0.990 ext prob = 0.057 for 100 years	0.087 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 85.592, lat 30.579
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18883	0.00157	121.1	636.0	0.02	0.18843	0.00197	96.5	507.0
0.04	0.00122	0.00035	544.6	2860.4	0.04	0.00137	0.00061	314.4	1651.2
0.06	0.00030	0.00005	3686.7	19362.8	0.06	0.00038	0.00022	847.5	4451.4
0.08	0.00004	0.00001	25265.4	99999.9	0.08	0.00013	0.00009	2007.0	10541.1
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00005	0.00004	4330.3	22743.2
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	8700.0	45693.3
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	16485.9	86585.6
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00001	0.00001	29685.4	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	51010.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	84009.2	99999.9
0.22	0.00000	0.00000	99999.9	99999.9	0.22	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.046 for 50 years	0.063 for 50 years
0.990 ext prob = 0.053 for 100 years	0.079 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 84.898, lat 30.588
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18888	0.00152	125.4	658.7	0.02	0.18845	0.00195	97.7	513.0
0.04	0.00120	0.00031	604.5	3174.7	0.04	0.00137	0.00058	329.8	1732.0
0.06	0.00027	0.00005	3819.6	20060.7	0.06	0.00037	0.00021	905.2	4754.0
0.08	0.00004	0.00001	33174.1	99999.9	0.08	0.00012	0.00009	2171.6	11405.3
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00005	0.00004	4744.5	24918.4
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	9683.0	50855.9
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	18754.4	98499.8
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	34816.0	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	62339.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.045 for 50 years	0.061 for 50 years
0.990 ext prob = 0.052 for 100 years	0.077 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 84.204, lat 30.593
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18893	0.00148	129.0	677.6	0.02	0.18852	0.00188	101.1	530.9
0.04	0.00117	0.00030	627.7	3296.5	0.04	0.00133	0.00056	342.0	1796.3
0.06	0.00025	0.00005	3681.9	19337.2	0.06	0.00035	0.00020	933.5	4903.0
0.08	0.00005	0.00001	33174.7	99999.9	0.08	0.00012	0.00009	2227.9	11700.9
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00005	0.00004	4842.7	25434.1
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	9836.4	51660.7
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	18969.3	99627.1
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	35080.4	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	62610.2	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.045 for 50 years	0.060 for 50 years
0.990 ext prob = 0.052 for 100 years	0.076 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 83.510, lat 30.595
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18898	0.00142	133.9	703.3
0.04	0.00112	0.00030	630.1	3309.1
0.06	0.00023	0.00008	2534.6	13312.1
0.08	0.00007	0.00001	33173.9	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18857	0.00182	104.4	548.1
0.04	0.00128	0.00054	349.5	1835.8
0.06	0.00034	0.00021	924.8	4857.2
0.08	0.00012	0.00009	2129.4	11183.7
0.10	0.00005	0.00004	4477.4	23516.0
0.12	0.00002	0.00002	8841.6	46437.4
0.14	0.00001	0.00001	16661.8	87510.1
0.16	0.00001	0.00001	30244.4	99999.9
0.18	0.00000	0.00000	53189.1	99999.9
0.20	0.00000	0.00000	91086.1	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

```
        zero attenuation variability                    variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                  0.000 for    1 years
    0.990 ext prob =  0.046 for    50 years                  0.061 for   50 years
    0.990 ext prob =  0.056 for   100 years                  0.077 for  100 years
  ratio  100 yr 0.990 extreme value to    1 yr val  =  0.00        0.00
```

Florida Panhandle Seismic Hazard
site at long 82.816, lat 30.593
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18910	0.00130	146.7	770.6
0.04	0.00096	0.00034	567.3	2979.7
0.06	0.00024	0.00010	2004.0	10524.9
0.08	0.00008	0.00001	16472.1	86512.3
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18866	0.00174	109.2	573.7
0.04	0.00121	0.00053	356.1	1870.2
0.06	0.00032	0.00021	891.4	4681.8
0.08	0.00012	0.00010	1951.1	10247.0
0.10	0.00005	0.00005	3940.5	20695.8
0.12	0.00002	0.00003	7536.9	39584.0
0.14	0.00001	0.00001	13836.8	72671.8
0.16	0.00001	0.00001	24567.7	99999.9
0.18	0.00000	0.00000	42383.4	99999.9
0.20	0.00000	0.00000	71343.2	99999.9
0.22	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

```
        zero attenuation variability                    variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                  0.000 for    1 years
    0.990 ext prob =  0.048 for    50 years                  0.062 for   50 years
    0.990 ext prob =  0.059 for   100 years                  0.079 for  100 years
  ratio  100 yr 0.990 extreme value to    1 yr val  =  0.00        0.00
```

Florida Panhandle Seismic Hazard
site at long 86.960, lat 29.954
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18924	0.00116	163.4	858.4
0.04	0.00093	0.00024	800.7	4205.2
0.06	0.00019	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18901	0.00139	137.0	719.3
0.04	0.00095	0.00044	436.3	2291.4
0.06	0.00027	0.00016	1169.2	6141.0
0.08	0.00009	0.00007	2741.8	14400.3
0.10	0.00004	0.00003	5853.4	30742.9
0.12	0.00002	0.00002	11687.2	61382.5
0.14	0.00001	0.00001	22188.3	99999.9
0.16	0.00000	0.00000	40463.6	99999.9
0.18	0.00000	0.00000	71332.4	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

```
        zero attenuation variability                    variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                  0.000 for    1 years
    0.990 ext prob =  0.042 for    50 years                  0.056 for   50 years
    0.990 ext prob =  0.051 for   100 years                  0.071 for  100 years
  ratio  100 yr 0.990 extreme value to    1 yr val  =  0.00        0.00
```

Florida Panhandle Seismic Hazard
site at long 86.270, lat 29.969
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18920	0.00120	158.2	830.7
0.04	0.00096	0.00025	767.8	4032.7
0.06	0.00020	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18892	0.00148	128.5	674.8
0.04	0.00103	0.00046	417.8	2194.4
0.06	0.00029	0.00017	1127.1	5919.4
0.08	0.00010	0.00007	2653.3	13935.5
0.10	0.00004	0.00003	5684.1	29853.5
0.12	0.00002	0.00002	11385.2	59796.4
0.14	0.00001	0.00001	21677.4	99999.9
0.16	0.00000	0.00000	39633.3	99999.9
0.18	0.00000	0.00000	70022.3	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.043 for 50 years	0.056 for 50 years
0.990 ext prob =	0.051 for 100 years	0.072 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Florida Panhandle Seismic Hazard
site at long 85.580, lat 29.981
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18923	0.00117	162.9	855.4
0.04	0.00091	0.00026	726.8	3817.4
0.06	0.00021	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18890	0.00150	126.9	666.3
0.04	0.00104	0.00046	416.2	2185.9
0.06	0.00029	0.00017	1112.7	5844.3
0.08	0.00010	0.00007	2599.9	13655.1
0.10	0.00004	0.00003	5549.3	29145.4
0.12	0.00002	0.00002	11104.4	58321.4
0.14	0.00001	0.00001	21153.8	99999.9
0.16	0.00000	0.00000	38725.2	99999.9
0.18	0.00000	0.00000	68519.8	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.043 for 50 years	0.057 for 50 years
0.990 ext prob =	0.052 for 100 years	0.073 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Florida Panhandle Seismic Hazard
site at long 84.890, lat 29.990
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18923	0.00117	162.3	852.4
0.04	0.00088	0.00029	660.4	3468.7
0.06	0.00024	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18890	0.00150	126.6	665.0
0.04	0.00103	0.00047	406.1	2132.7
0.06	0.00029	0.00018	1065.9	5598.5
0.08	0.00010	0.00008	2469.1	12967.8
0.10	0.00004	0.00004	5259.0	27621.0
0.12	0.00002	0.00002	10538.4	55348.6
0.14	0.00001	0.00001	20135.5	99999.9
0.16	0.00000	0.00001	36993.2	99999.9
0.18	0.00000	0.00000	65696.4	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

	zero attenuation variability	variability in atten, sigma=0.50
sol not obtained for time=		
sol not obtained for time=		
0.990 ext prob =	0.000 for 1 years	0.000 for 1 years
0.990 ext prob =	0.044 for 50 years	0.058 for 50 years
0.990 ext prob =	0.052 for 100 years	0.074 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val =	0.00	0.00

Florida Panhandle Seismic Hazard
site at long 84.200, lat 29.995
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18920	0.00120	158.7	833.8	0.02	0.18890	0.00150	126.8	665.9
0.04	0.00090	0.00030	629.5	3306.2	0.04	0.00102	0.00048	398.5	2093.1
0.06	0.00025	0.00005	3819.6	20060.7	0.06	0.00029	0.00018	1036.0	5441.1
0.08	0.00004	0.00001	33174.2	99999.9	0.08	0.00010	0.00008	2392.9	12567.7
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	5098.5	26777.9
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	10234.0	53749.8
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	19596.0	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	36081.4	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	64218.5	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
totel yearly events		0.19040			total yearly events		0.19040		

zero ettenuation variability	variability in etten, sigma=0.50
sol not obteined for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.045 for 50 years	0.058 for 50 years
0.990 ext prob = 0.052 for 100 years	0.074 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 83.510, lat 29.997
shortest dist to fault= 9999.999 km

zero ettenuation variability					variability in atten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18923	0.00117	163.4	858.0	0.02	0.18895	0.00145	131.6	691.3
0.04	0.00086	0.00030	629.8	3307.5	0.04	0.00098	0.00047	409.0	2148.1
0.06	0.00025	0.00005	3807.9	19999.5	0.06	0.00028	0.00018	1052.1	5525.5
0.08	0.00004	0.00001	33174.0	99999.9	0.08	0.00010	0.00008	2414.7	12682.5
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	5126.2	26923.3
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	10266.4	53920.5
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	19630.0	99999.9
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	36109.1	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	64228.2	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
totel yearly events		0.19040			total yearly events		0.19040		

zero attenuation variability	variebility in atten, sigma=0.50
sol not obteined for time=	
sol not obtained for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.045 for 50 years	0.058 for 50 years
0.990 ext prob = 0.052 for 100 years	0.074 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 82.819, lat 29.995
shortest dist to fault= 9999.999 km

zero attenuation variability					variability in etten, sigma= 0.50				
g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18929	0.00111	170.9	897.7	0.02	0.18900	0.00140	136.4	716.3
0.04	0.00081	0.00030	629.9	3308.5	0.04	0.00094	0.00045	418.9	2200.3
0.06	0.00024	0.00006	3076.7	16159.3	0.06	0.00027	0.00018	1053.9	5535.1
0.08	0.00006	0.00001	33173.9	99999.9	0.08	0.00010	0.00008	2364.8	12420.5
0.10	0.00001	0.00000	99999.9	99999.9	0.10	0.00004	0.00004	4923.0	25856.3
0.12	0.00000	0.00000	99999.9	99999.9	0.12	0.00002	0.00002	9702.1	50956.6
0.14	0.00000	0.00000	99999.9	99999.9	0.14	0.00001	0.00001	18311.6	96174.6
0.16	0.00000	0.00000	99999.9	99999.9	0.16	0.00000	0.00001	33336.0	99999.9
0.18	0.00000	0.00000	99999.9	99999.9	0.18	0.00000	0.00000	58808.1	99999.9
0.20	0.00000	0.00000	99999.9	99999.9	0.20	0.00000	0.00000	99999.9	99999.9
total yearly events		0.19040			total yearly events		0.19040		

zero attenuation veriability	veriebility in etten, sigma=0.50
sol not obtained for time=	
sol not obteined for time=	
0.990 ext prob = 0.000 for 1 years	0.000 for 1 years
0.990 ext prob = 0.045 for 50 years	0.058 for 50 years
0.990 ext prob = 0.054 for 100 years	0.075 for 100 years
ratio 100 yr 0.990 extreme velue to 1 yr val = 0.00	0.00

Florida Panhandle Seismic Hazard
site at long 86.941, lat 29.356
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18945	0.00095	201.1	1056.1
0.04	0.00074	0.00020	940.4	4939.1
0.06	0.00015	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18924	0.00116	164.5	863.8
0.04	0.00080	0.00036	526.6	2765.7
0.06	0.00022	0.00014	1383.0	7263.8
0.08	0.00008	0.00006	3169.3	16645.5
0.10	0.00003	0.00003	6627.6	34809.1
0.12	0.00001	0.00001	13005.0	68303.4
0.14	0.00001	0.00001	24337.6	99999.9
0.16	0.00000	0.00000	43857.0	99999.9
0.18	0.00000	0.00000	76554.0	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years
0.990 ext prob = 0.040 for 50 years
0.990 ext prob = 0.050 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00

variability in atten, sigma=0.50
0.000 for 1 years
0.052 for 50 years
0.068 for 100 years
0.00

Florida Panhandle Seismic Hazard
site at long 86.255, lat 29.371
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18946	0.00094	201.7	1059.4
0.04	0.00074	0.00021	918.3	4822.9
0.06	0.00016	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18922	0.00118	161.6	848.5
0.04	0.00081	0.00037	521.3	2737.8
0.06	0.00023	0.00014	1368.3	7186.4
0.08	0.00008	0.00006	3132.5	16452.0
0.10	0.00003	0.00003	6549.9	34401.0
0.12	0.00001	0.00001	12859.1	67537.5
0.14	0.00001	0.00001	24084.2	99999.9
0.16	0.00000	0.00000	43440.1	99999.9
0.18	0.00000	0.00000	75890.8	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years
0.990 ext prob = 0.040 for 50 years
0.990 ext prob = 0.050 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00

variability in atten, sigma=0.50
0.000 for 1 years
0.052 for 50 years
0.068 for 100 years
0.00

Florida Panhandle Seismic Hazard
site at long 85.569, lat 29.383
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18945	0.00095	201.2	1056.5
0.04	0.00071	0.00024	809.7	4252.8
0.06	0.00019	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18918	0.00122	156.1	819.9
0.04	0.00084	0.00038	499.0	2620.6
0.06	0.00023	0.00015	1290.0	6775.1
0.08	0.00008	0.00006	2931.3	15395.7
0.10	0.00003	0.00003	6126.3	32176.2
0.12	0.00002	0.00002	12066.0	63371.6
0.14	0.00001	0.00001	22705.3	99999.9
0.16	0.00000	0.00000	41162.7	99999.9
0.18	0.00000	0.00000	72265.6	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years
0.990 ext prob = 0.042 for 50 years
0.990 ext prob = 0.051 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00

variability in atten, sigma=0.50
0.000 for 1 years
0.053 for 50 years
0.069 for 100 years
0.00

Florida Panhandle Seismic Hazard
site at long 84.882, lat 29.392
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18946	0.00094	203.0	1066.0
0.04	0.00068	0.00026	732.1	3845.0
0.06	0.00021	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18917	0.00123	154.3	810.6
0.04	0.00084	0.00039	485.8	2551.3
0.06	0.00024	0.00015	1234.6	6484.2
0.08	0.00009	0.00007	2781.6	14609.5
0.10	0.00004	0.00003	5802.9	30477.6
0.12	0.00002	0.00002	11448.9	60131.0
0.14	0.00001	0.00001	21615.3	99999.9
0.16	0.00000	0.00000	39336.3	99999.9
0.18	0.00000	0.00000	69323.8	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years
0.990 ext prob = 0.043 for 50 years
0.990 ext prob = 0.052 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00

variability in atten, sigma=0.50
0.000 for 1 years
0.054 for 50 years
0.071 for 100 years
0.00

Florida Panhandle Seismic Hazard
site at long 84.196, lat 29.397
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18946	0.00094	201.9	1060.2
0.04	0.00066	0.00028	673.6	3537.6
0.06	0.00023	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18916	0.00124	154.0	808.9
0.04	0.00083	0.00040	473.1	2484.7
0.06	0.00024	0.00016	1184.0	6218.3
0.08	0.00009	0.00007	2651.2	13924.4
0.10	0.00004	0.00003	5527.5	29030.9
0.12	0.00002	0.00002	10927.5	57392.6
0.14	0.00001	0.00001	20695.0	99999.9
0.16	0.00000	0.00001	37790.9	99999.9
0.18	0.00000	0.00000	66826.6	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years
0.990 ext prob = 0.044 for 50 years
0.990 ext prob = 0.052 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00

variability in atten, sigma=0.50
0.000 for 1 years
0.055 for 50 years
0.072 for 100 years
0.00

Florida Panhandle Seismic Hazard
site at long 83.510, lat 29.398
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18945	0.00095	200.8	1054.6
0.04	0.00065	0.00030	630.9	3313.8
0.06	0.00025	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18916	0.00124	153.4	805.6
0.04	0.00083	0.00041	462.1	2426.9
0.06	0.00025	0.00017	1143.2	6004.1
0.08	0.00009	0.00007	2548.9	13387.0
0.10	0.00004	0.00004	5312.9	27903.7
0.12	0.00002	0.00002	10521.0	55257.2
0.14	0.00001	0.00001	19974.5	99999.9
0.16	0.00000	0.00001	36575.3	99999.9
0.18	0.00000	0.00000	64851.0	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

zero attenuation variability
sol not obtained for time=
sol not obtained for time=
0.990 ext prob = 0.000 for 1 years
0.990 ext prob = 0.045 for 50 years
0.990 ext prob = 0.052 for 100 years
ratio 100 yr 0.990 extreme value to 1 yr val = 0.00

variability in atten, sigma=0.50
0.000 for 1 years
0.056 for 50 years
0.073 for 100 years
0.00

Florida Panhandle Seismic Hazard
site at long 82.823, lat 29.397
shortest dist to fault= 9999.999 km

zero attenuation variability

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18943	0.00097	196.5	1032.0
0.04	0.00067	0.00030	629.5	3306.2
0.06	0.00025	0.00005	3819.6	20060.7
0.08	0.00004	0.00001	33174.1	99999.9
0.10	0.00001	0.00000	99999.9	99999.9
0.12	0.00000	0.00000	99999.9	99999.9
0.14	0.00000	0.00000	99999.9	99999.9
0.16	0.00000	0.00000	99999.9	99999.9
0.18	0.00000	0.00000	99999.9	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

variability in atten, sigma= 0.50

g.m.	occ/yr	exc/yr	r(events)	r(yrs)
0.02	0.18921	0.00119	159.6	838.3
0.04	0.00078	0.00041	463.9	2436.6
0.06	0.00024	0.00017	1138.8	5980.9
0.08	0.00009	0.00008	2537.5	13327.0
0.10	0.00004	0.00004	5292.5	27796.5
0.12	0.00002	0.00002	10487.9	55083.6
0.14	0.00001	0.00001	19922.7	99999.9
0.16	0.00000	0.00001	36495.3	99999.9
0.18	0.00000	0.00000	64735.1	99999.9
0.20	0.00000	0.00000	99999.9	99999.9

total yearly events 0.19040

```
        zero attenuation variability                  variability in atten, sigma=0.50
sol not obtained for time=
sol not obtained for time=
    0.990 ext prob =  0.000 for     1 years                     0.000 for    1 years
    0.990 ext prob =  0.045 for    50 years                     0.056 for   50 years
    0.990 ext prob =  0.052 for   100 years                     0.073 for  100 years
  ratio  100 yr 0.990 extreme value to    1 yr val   =   0.00         0.00
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BIOGRAPHICAL SKETCH

Kenneth Lord was born into what most would consider to be a typical American family, complete with one brother, two sisters, one dog, one station wagon, and a house in suburban Pittsburgh. Although the house near Pittsburgh was eventually abandoned for others in New Jersey and suburban Philadelphia, the other factors (including the dog and the station wagon) remained constant until Mr. Lord left to attend the University of Miami, where he began working towards degrees in anthropology and geology.

As a sophomore, Mr. Lord began working for the University of Miami police department and was soon offered the opportunity to attend the Broward Police Academy. After graduating as class valedictorian, Mr. Lord returned to the University of Miami, where he worked full-time and attended school full-time. Following graduation from Miami, he worked for a time for the police department in Plantation, Florida, and subsequently enrolled in the graduate program at the University of Florida.

Although Mr. Lord chose geophysics as an academic specialization, he also worked for E. I. DuPont de Nemours and Co. doing mineral exploration and hydrogeologic assessments. After finishing his thesis, titled "The Tectonic Evaluation of a Gravity Survey Along the Eastern Coastal Plain of Georgia," Mr. Lord

continued working for DuPont for a short time and then returned to the University of Florida to work on a doctorate degree.

Mr. Lord's plans include attending law school at Cornell University, where he intends to specialize in environmental and natural resources law. They do not include either a dog or a station wagon.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Douglas L. Smith, Chair
Professor of Geology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Thomas L. Crisman
Professor of Environmental Engineering Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Paul A. Mueller
Professor of Geology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Neil D. Opdyke
Professor of Geology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Anthony F. Randazzo
Professor of Geology

This dissertation was submitted to the Graduate Faculty of the Department of Geology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August, 1993

Dean, Graduate School